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WATER QUALITY STUDY OF RUNOFF FROM AGRICULTURAL LANDS

Old West Regional Commission
March 1978

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Prepared for the Old West Regional Commission
by the Nebraska Water Resources Center
University of Nebraska-Lincoln

Old West Regional Commission
March 1978

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A project of this nature cannot be conducted without the active support of numerous organizations and individuals. The interest and cooperation of the farmers and land owners in the watershed during this study was deeply appreciated and was essential to the satisfactory completion of the project. Likewise, the assistance provided by Mr. Hal Shroeder, General Manager, Mr. Glen Johnson, Assistant General Manager, and the directors of the Nebraska Lower Platte South Natural Resources District was appreciated.

During the study period, personnel from the U.S. Department of Agriculture, Soil Conservation Service conducted a soil survey of the study watershed. Results of this survey are included in the final report on this project.

Dr. Thomas M. McCalla, Research Leader, Soil Microbiologist, U. S. Department of Agriculture, Agricultural Research Service, is Director of the Agronomy Laboratory at the University of Nebraska-Lincoln where field samples for this project were analyzed. Mr. Joseph Vavricka was the field technician in charge of sampling and field data collection.

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I. INTRODUCTION

Necessity for increased reuse of water and concern over possible detrimental effects resulting from the discharge of various wastes has resulted in the adoption and enforcement of regulations designed to protect the quality of the nation's waters. Initially, primary concern was focused on point source waste discharges such as the effluent from municipal and industrial wastewater treatment plants. However, it is now apparent that nonpoint waste discharges, such as storm runoff from rural and urban areas, can significantly influence the quality of water in receiving streams and that some controls over these discharges will be required in order to meet desired water quality standards.

As indicated, storm runoff constitutes a major source of nonpoint source waste discharge to surface waters. Because of the unpredictability of such events, the difficulty and costs associated with determination of the quantity and quality of such runoff and the relatively recent recognition of the significance of these discharges on water quality, limited data are available for evaluating possible control requirements. One of the goals of this study was to obtain data on the quantity and quality of runoff from an agricultural area. For this purpose a 7.8 square mile drainage area in eastern Nebraska was instrumented and monitored for a 30 month period.

Some mathematical models have recently been developed for simulating the quantity and quality of storm runoff. Unfortunately, data for model evaluation and calibration are very limited. Therefore, another goal of this study was to use the data obtained to evaluate the effectiveness of available models for simulating the runoff from the study watershed. The models used for this purpose, ARM (Agricultural Runoff Management) and NPS

(Nonpoint Source Pollutant Loading Model), were developed by Hydrocomp, Inc, for and in cooperation with the U.S. Environmental Protection Agency.

II. DESCRIPTION OF STUDY WATERSHED

The watershed selected for this study, Dee Creek, is located approximately 15 miles northeast of Lincoln, Nebraska. Some of the factors considered in the selection of this watershed were: (1) it was considered representative of productive agricultural land in the region; (2) soil conservation practices were used on a relatively high percentage of the watershed; (3) the topography, soil and cropping practices in the basin are relatively uniform; (4) farmers and land owners in the study area were interested in the project and willing to cooperate in supplying desired data; and (5) the site was readily accessible to personnel from the University of Nebraska-Lincoln.

The portion of the Dee Creek watershed studied has an area of approximately 7.8 square miles (5,000 acres) and is located in the southern half of Township TIIN, R9E of Cass County Nebraska. A topographic map of the watershed is presented in Figure 1. Data from this map were used to obtain the computer plot of the watershed shown in Figure 2. The control structure across the channel of Dee Creek and the associated flow measurement and sampling equipment used for this study are located at the base of the drainage area. Some of this equipment was installed as part of another project prior to the start of this study. Photographs of the watershed are included in Figures 3-6.

Topography of the watershed ranges from nearly flat bottom lands to gentle and in some cases, strong slopes on uplands. During the study, the Soil Conservation Service of the United States Department of Agriculture made a detailed soil survey of the Dee Creek watershed. It was found that over 90 percent of the soil consisted of silty clay loam--primarily the Sharpsburg series formed in loess. A copy of the report on this survey, "Advance Soil Map Soil Descriptions and Soil Interprelations for Dee Creek Watershed Cass County, Nebraska, June, 1976," is attached to this report.

Figure 1: Topographic map of Dee Creek Watershed

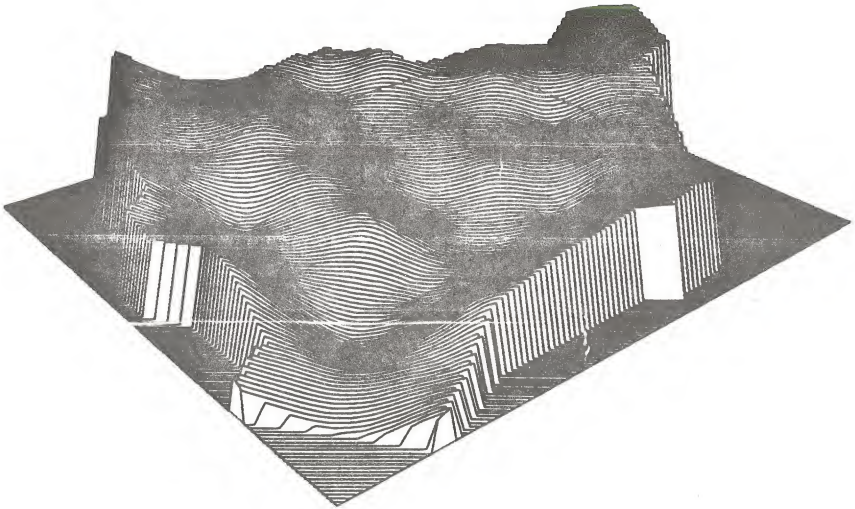


Figure 2: Computer plot contour map of Dee Creek Watershed

Figure 3: Aerial photograph of a portion of the Dee Creek Watershed, Lincoln, Nebraska

Figure 4: Aerial photograph of a portion of the Dee Creek Watershed, Lincoln, Nebraska

Figure 5: View showing the building housing the automatic sampling equipment the bridge for observation and manual sampling, the flow measuring equipment and the lower portion of the Dee Creek drainage basin.

Figure 6: A view looking downstream at the control structure. The USGS stream gauging station used for calibrating the control structure is located at the county road bridge in the background.

As mentioned previously, the watershed is located in a very productive agricultural area. Primary crops grown in the basin are milo, wheat, soybeans, corn, brome (pasture), alfalfa and clover. Acreage of each crop varies depending upon economic and weather conditions. Irrigation was not used in the watershed. Since this study was designed to evaluate runoff from a "typical" agricultural area in the region, no attempt was made to alter or regulate farming practices.

III. WATERSHED INSTRUMENTATION AND DATA COLLECTION

Some of the instrumentation used for this study was installed as part of a preceeding related project. A control structure, which was located at the base of the study watershed, consisted of sheet piling placed across the channel in a specified configuration. (See Figure 6.) Width of the center, level section of the structure was 13 feet. Gabions (wire mesh baskets) were filled with rocks and placed against the downstream face of the structure to control erosion. A flow rating curve for this structure was obtained from velocity and depth measurements at a U.S. Geological Survey gauging station located approximately 300 feet downstream from the control structure.

Depth of flow over the structure was continuously measured by the two Stevens flow recorders--one using a 24-hour chart and the other a 7-day chart. The recorders were placed on top of a two foot diameter, corrugated metal pipe placed vertically in the creek bank approximately 20 feet upstream from the control structure. This pipe, which was set in concrete, served as a stilling well for depth of flow measurements and was connected to the stream by two, six-inch diameter corrugated metal pipes.

Automatic flow sampling equipment consisted of two Federal Interagency Sedimentation Project PS-69 Pumping Samplers. Each of the battery operated units was capable of collecting 72 samples without servicing. The samplers, which were operated in series, were activated when the recorded depth of flow in the stream increased by a set value above base flow conditions. Once activated, the samplers continued to sample at 15 minute intervals during the runoff event until the flow dropped below the activation level. Initially, the samplers were set to commence sampling at a 0.3 foot rise in the depth of flow above the control structure. Due to the limited runoff which occurred during the study, this was later adjusted so the units were activated by a 0.2 foot rise in the stream.

Since heat was not provided in the sheet metal building housing the sampler units, they were disconnected during cold weather. During these periods, samples were collected manually. Samples of base flow in the creek were also collected manually. Personnel from the Agricultural Research Service of the U.S. Department of Agriculture at the University of Nebraska-Lincoln serviced the equipment and collected the field data. Samples were analyzed in the U.S. Agricultural Research Laboratory, Department of Agronomy, University of Nebraska-Lincoln.

Instrumentation was also provided for continuously monitoring the dissolved oxygen, pH, temperature and conductivity of the stream at the control structure. Unfortunately, severe operational problems were encountered with this equipment and this portion of the study was discontinued after approximately six months.

Initially, it was planned that a subbasin of the watershed--a cattle feedlot--would also be instrumental for evaluating runoff. Due to unfavorable economic conditions, the feedlot was closed shortly after the start of the project and this portion of the study was not implemented.

During warm weather, precipitation on the watershed was measured by eight continuous recording rain gauges. Locations of these gauges and the resulting Thiessen network used for calculated weighted precipitation on the basin are shown in Figure 7. During cold weather, only two gauges--Nos. 3 and 9--were operated and the Thiessen network was adjusted accordingly.

Nitrogen determinations were made on a limited number of precipitation samples. For this purpose, acid washed glass containers were placed in the weighing buckets of the rain gauges.

Data relative to farming practices were obtained from questionnaires, personal interviews and field observation.

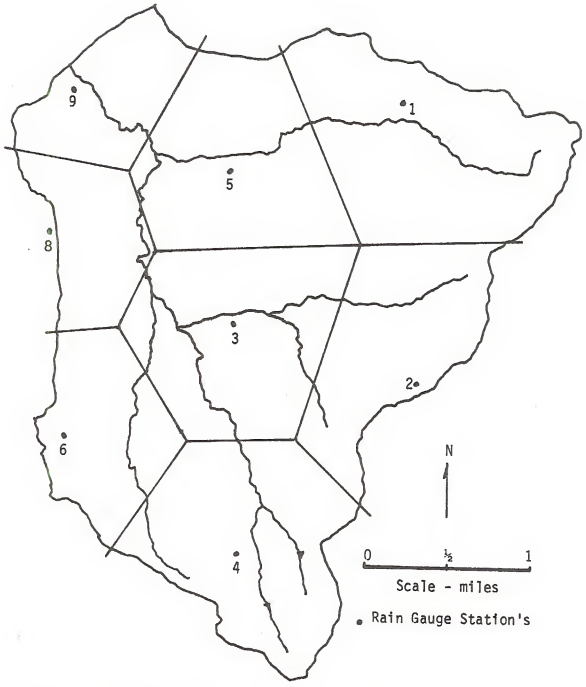


Figure 7: Location of Rain Gauges and the Associated Thiessen Network for the Dee Creek Watershed

IV. PRESENTATION AND DISCUSSION OF STUDY DATA

A major objective of this study was to obtain data on the quantity and quality of runoff from an agriculturally oriented watershed. Obviously, such data are dependent upon weather conditions. During the period of this study--July 1, 1974 through December 31, 1976--unusually dry weather conditions existed in the area of the study. The severity of this drought is apparent from precipitation data presented in Tables 1-4. Precipitation for each year of the study was approximately 12 inches below normal or amounts to 60 percent of the normal annual precipitation. As a result, the number and magnitude of runoff events was quite limited.

In one aspect, the unusual weather conditions which prevailed adversely affected the results of the study. On the other hand, data were obtained for weather conditions which may not reoccur for 20-30 years, and in this sense the information obtained is especially valuable. However, in the use of these data it must be recognized that severe dry weather conditions prevailed and as a result extreme caution must be used in possible application of this information to anticipated values for normal weather conditions.

Crop information for the watershed is summarized in Table 5. With the exception of corn, crop yeilds were quite good considering the limited precipitation. Shifts in crop acreages reflect economic considerations and weather factors. Likewise, the sharp reduction in cattle numbers during the study period resulted from unfavorable economic factors and uncertain pasture conditions. Livestock data are shown in Table 6.

Information on fertilizer applications for the various crops is included in Table 5. Generally, the per acre application of fertilizer remained relatively constant for a given crop. Major variations were a doubling of nitrogen application for oats--15lb/acre to 34 lb/acre--during the study period and a marked reduction

Table 1
Precipitation Data
Dee Creek Watershed-Lincoln, Nebraska

	Normal Precipitation (in.)*		Recorded Precipitation (in.)**		
	Lincoln (City)	North Omaha	1974	1975	1976
January	0.78	0.69	Nil	1.06	0.25
February	1.12	0.96	0.15	0.57	0.74
March	1.67	1.62	0.62	1.64	2.54
April	2.61	2.82	2.47	1.94	3.53
May	3.65	3.99	3.59	2.21	3.59
June	5.37	4.93	1.11	3.80	0.56
July	3.60	3.71	0.20	1.03	1.03
August	3.45	4.01	4.33	1.53	1.07
September	3.32	3.16	0.36	1.11	3.41
October	1.73	1.76	2.38	Nil	0.22
November	1.02	1.01	0.96	2.54	Nil
December	0.88	0.77	0.33	0.39	Nil
Annual	29.20	29.43	16.50	17.82	16.94

*Normal precipitation for the indicated weather stations for the period 1941-1970.

**Weighted precipitation on the Dee Creek Watershed based on a Thiessen diagram for rainfall gauging stations in operation.

Table 2
Precipitation Data-1974
Dee Creek Watershed-Lincoln, Nebraska
(Total Annual Precipitation for 1974 = 16.50 inches)

Date	Precipitation (in.)*	Type of Precipitation
Feb. 21	0.15	Snow
Mar. 4	0.26	Rain
11	0.11	Rain
15	0.15	Rain
21	0.10	Rain
Apr. 3	0.20	Rain
11	0.36	Rain
13	0.71	Rain
15	0.31	Rain
28	0.89	Rain
May 2	0.10	Rain
9	0.32	Rain
10	1.34	Rain
17	0.52	Rain
18	0.26	Rain
21	0.06	Rain
25	0.20	Rain
27	0.08	Rain
30	0.71	Rain
June 5	0.51	Rain
8	0.42	Rain
11	0.18	Rain
July 22	0.20	Rain
Aug. 8	1.42	Rain
10	0.18	Rain
14	0.07	Rain
15	0.18	Rain
16	1.89	Rain
17	0.27	Rain
27	0.23	Rain
30	0.07	Rain
31	0.02	Rain
Sept. 1	0.01	Rain
5	0.09	Rain
12	0.26	Rain
Oct. 5	0.65	Rain
11	0.08	Rain
12	0.01	Rain
13	0.01	Rain
28	0.30	Rain
30	1.33	Rain
Nov. 3	0.49	Rain
9	0.47	Rain
Dec. 6	0.09	Snow
14	0.09	Snow
19	0.15	Snow

*Weighted precipitation based on a Thiessen diagram for rainfall gauging stations in operation.

Table 3
Precipitation Data-1975
Dee Creek Watershed-Lincoln, Nebraska
(Total Annual Precipitation for 1975 = 17.82 inches)

Date		Precipitation (in.)*	Type of Precipitation
Jan.	3	0.17	Snow
	6	0.40	Snow
	20	0.28	Snow
	28	0.21	Snow
Feb.	1	0.20	Snow
	17	0.37	Snow
Mar.	10	0.24	Snow
	18	0.23	Rain
	21	0.17	Rain
	22	1.00	Rain
Apr.	7	0.18	Rain
	13	0.32	Rain
	18	0.46	Rain
	20	0.09	Rain
	22	0.57	Rain
	27	0.32	Rain
May	2	0.22	Rain
	9	0.49	Rain
	27	1.17	Rain
	29	0.26	Rain
	31	0.07	Rain
June	2	0.82	Rain
	4	0.15	Rain
	8	0.81	Rain
	10	0.32	Rain

1975 Continued

Date		Precipitation (in.)*	Type of Precipitation
June	11	0.09	Rain
	15	0.08	Rain
	18	1.03	Rain
	21	0.16	Rain
	23	0.14	Rain
	24	0.20	Rain
July	7	0.09	Rain
	8	0.11	Rain
	19	0.19	Rain
	21	0.64	Rain
Aug.	1	0.33	Rain
	10	0.05	Rain
	13	0.43	Rain
	14	0.54	Rain
	24	0.01	Rain
	28	0.17	Rain
Sept.	3	0.06	Rain
	4	0.36	Rain
	10	0.52	Rain
	28	0.13	Rain
	30	0.04	Rain
Nov.	9	0.51	Rain
	19	1.54	Rain
	27	0.49	Snow
Dec.	8	0.05	Snow
	13	0.34	Snow

*Weighted precipitation based on a Thiessen diagram for rainfall gauging stations in operation.

Table 4
Precipitation Data-1976
Dee Creek Watershed-Lincoln, Nebraska
(Total Annual Precipitation for 1976 = 16.94 inches)

Date	Precipitation (in.)*	Type of Precipitation
Jan. 31	0.25	Snow
Feb. 14	0.14	Snow
16	0.37	Rain
20	0.23	Snow
Mar. 4	0.53	Snow
5	0.13	Snow
29	1.57	Rain
30	0.31	Rain
Apr. 6	0.87	Rain
14	0.24	Rain
15	0.49	Rain
17	0.25	Rain
20	0.23	Rain
23	0.43	Rain
24	0.42	Rain
27	0.60	Rain
May 12	0.84	Rain
13	0.03	Rain
15	0.54	Rain
16	0.31	Rain
22	1.29	Rain
23	0.41	Rain
28	0.02	Rain
29	0.15	Rain
June 11	0.03	Rain
23	0.49	Rain
24	0.04	Rain
July 2	0.25	Rain
21	0.62	Rain
22	0.10	Rain
29	0.06	Rain
Aug. 9	0.06	Rain
13	0.30	Rain
14	0.71	Rain
Sept. 9	0.10	Rain
13	0.15	Rain
15	0.12	Rain
17	0.04	Rain
19	1.30	Rain
23	0.24	Rain
24	0.26	Rain
25	1.20	Rain
Oct. 18	0.20	Rain
30	0.02	Rain

*Weighted precipitation based on a Thiessen diagram for rainfall gauging stations in operation.

Table 5
Crop Information
Dee Creek Watershed-Lincoln, Nebraska

	Reporting Year		
	1973-74	1974-75	1975-76*
Milo			
acres	1,867	1,915	2,458
ave. yield, bu/acre	48	69	78
ave. fertilizer applied			
nitrogen, lb/acre	85	72	85
phosphorus, lb/acre	1.7	0.0	2.3
potassium, lb/acre	2.6	0.0	0.4
Wheat			
acres	755	1,014	438
ave. yield, bu/acre	47	40	38
ave. fertilizer applied			
nitrogen, lb/acre	43	36	41
phosphorus, lb/acre	18	21	23
potassium, lb/acre	1.3	3.2	6.0
Soybeans			
acres	496	566	359
ave. yield, bu/acre	26	30	19
ave. fertilizer applied			
nitrogen, lb/acre	0.0	1.2	0.0
phosphorus, lb/acre	0.0	0.0	0.0
potassium, lb/acre	0.0	0.0	0.0
Corn			
acres	224	61	96
ave. yield, bu/acre	30	40	48
ave. fertilizer applied			
nitrogen, lb/acre	72	75	82
phosphorus, lb/acre	0	0	0
potassium, lb/acre	0	0	0
Oats			
acres	30	120	361
ave. yiels, bu/acre	80	64	62
ave. fertilizer applied			
nitrogen, lb/acre	15	30	34
phosphorus, lb/acre	0.0	0.0	0.9
potassium, lb/acre	0.0	0.0	0.9

Crop Information Cond't

	1973-74	1974-75	1975-76
Brome			
acres	440	339	315
ave. fertilizer applied			
nitrogen, lb/acre	59	31	30
phosphorus, lb/acre	0.0	0.0	0.0
potassium, lb/acre	0.0	0.0	0.0
Sudan			
acres	3	0.0	10
ave. fertilizer applied			
nitrogen, lb/acre	60	-	0.0
phosphorus, lb/acre	0.0	-	0.0
potassium, lb/acre	0.0	-	0.0
Red Clover			
acres	140	182	168
Sweet Clover			
acres	17	34	36
Alfalfa			
acres	106	85	82
ave. yield, ton/acre	4.6	3.6	2.7
Prairie Hay			
acres	12	14	0.0
ave. yield, ton/acre	-	1.7	-
Summer Fallow			
acres	0	35	60
Other (waterways, building, fences, etc)			
acres	260	80	45
Total Area Reported **			
acres	4,350	4,445	4,428

*Due to the accidental death of one farmer, data were not obtained for a 320 acre farm.

**Area in the study watershed is 5,000 acres based on data obtained from the United States Geological Survey and measurements from topographic maps. Most of the variance between measured and reported acres is attributed to roadways, waterways, building lots, fences and small acreages not reported.

Table 6
Livestock Data
Dee Creek Watershed-Lincoln, Nebraska

	Reporting Year		
	1974	1975	1976
Cattle*			
Pastured			
Cows	290	145	120
Calves	135	65	80
Feeders	295	155	30
Confined (Feedlot)	40	100	10
Total	760	465	240
Swine	200	160	200

*Period of grazing is generally April through October. Thus some cattle reported as feeders on pasture may also be included in the confined (feedlot) category.

in nitrogen use for brome--59 lb/acre to 30 lb/acre. It should be noted that there was a significant increase in oat acreage during the period and that the value reported for 1973-74 was based on only 30 acres. Reduction in nitrogen application on brome was attributed to increased cost reduction in livestock numbers and carryover due to limited rainfall. Because winter wheat is grown in the study watershed, the reporting year listed in Table 5 is given as 1973-74, etc.

Total reported fertilizer usage in the watershed is summarized in Table 7. The reduction in fall application of fertilizer and associated increase in spring usage resulted from the decrease in wheat acreage and increases in planting of milo and oats. The overall reduction during 1974-75 is attributed to shortages in fertilizer supplies and increased costs.

A limited number of precipitation samples were analyzed for nitrogen concentrations. Results obtained are given in Table 8. Neglecting variances in the quantity of precipitation involved, the average total nitrogen concentration of these samples was 0.86 mg/l as nitrogen. Assuming a conservative, average concentration of nitrogen 0.50 mg/l and a normal annual precipitation of 29 inches, this amounts to approximately 3.3 pounds of nitrogen per acre per year.

In May, 1976, surface soil samples were collected from various points in the study watershed and were analyzed for nitrate and phosphorus concentrations. Results of these analyses are presented in Table 9. The highest concentration of nitrate nitrogen as determined by extraction with a KCL solution was 102 ppm. This sample was collected from a field of brome which had recently been fertilized. Except for this sample, nitrate concentrations ranged from 2.5 to 26 ppm and phosphorus concentrations ranged from 4.6 to 49 ppm. It was felt that nutrient concentrations might vary significantly depending on crops raised. Data indicate nitrate concentrations in fields

Table 7
Fertilizer Applied
Dee Creek Watershed-Lincoln, Nebraska

	Reporting Year		
	1973-74[1]	1974-75	1975-76[2]
Nitrogen			
Fall Application			
Broadcast (tons)	20.1	16.0	9.0
Spray (tons)	3.4	1.2	0.0
Sub-surface (tons)	0.0	10.9	0.0
Total (tons)	23.5	28.1	9.0
Spring Application			
Broadcast (tons)	11.2	2.3	10.5
Spray (tons)	4.5	7.0	7.0
Sub-surface (tons)	78.4	56.2	101.5
Total (tons)	94.1	65.5	119.0
Annual Application			
tons	117.6	93.6	128.0
lbs/reported acre[3]	54	42	58
lbs/watershed acre	46.3	36.9	50
Phosphorus			
Fall Application			
tons	1.6	10.5	5.1
Spring Application			
tons	6.7	0.0	3.6
Annual Application			
tons	8.3	10.5	8.7
lbs/reported acre	3.8	4.7	3.9
lbs/watershed acre	3.3	4.2	3.4
Potassium			
Fall Application			
tons	0.5	1.6	1.3
Spring Application			
tons	2.4	0.0	0.7
Annual Application			
tons	2.9	1.6	2.0
lbs/reported acre	1.3	0.7	0.9
lbs/watershed acre	1.1	0.6	0.8

Fertilizer Applied Cont'd

1. An additional 50 tons of organic fertilizer (hog manure) was applied during this period.

2. During 1975-76, 36 acres of sweet clover was also plowed under.

3. During the study period, acres reported farmed in the watershed totaled 4,350 in 1973-74, 4,445 in 1974-75 and 4,428 in 1975-76. Most of the variance from the 5,000 acres determined to be in the watershed from topographic maps may be attributed to roadways, waterways, small acreages not reported and building lots.

Table 8
Nitrogen Analyses of Precipitation
Dee Creek Watershed-Lincoln, Nebraska

Date	NH_3-N mg/l	NO_3-N mg/l
August 13, 1975	0.56	0.66
August 14, 1975	0.67	0.60
August 14, 1975	0.72	0.36
August 29, 1975	0.51	3.0
August 29, 1975	1.9	1.9
April 24, 1976	1.5	0.93
April 27, 1976	0.34	0.22
May 27, 1976	0.57	0.48
Jan. 31, 1976	0.37	0.18

Table 9
Laboratory Analyses of Soil Samples Collected May 26, 1976[1]
Dee Creek Watershed-Lincoln, Nebraska

Land Use or Condition[2]	Soil Nutrient Concentration	
	$N\text{-}NO_3$- (ppm)	P (ppm)
Brome Pasture		
1 (spring fertilized)	102	39
2	9.9	49
3	2.5	13
Corn		
1	8.4	22
2	11	21
Milo		
1	11	7.7
2	9.6	7.3
3*	17	15
4*	17	8.8
5	15	19
6	21	14
Oats		
1	6.9	7.3
2	15	15
Soybeans		
1*	11	11
Wheat		
1	9.7	16
2	7.9	20
3	8.8	12
Disked		
1	13	20
2	13	22
3 (corn)	17	16
4 (milo)	11	11
5	16	7.0

Laboratory Analyses of Soil Samples Collected May 26, 1976 Cond't

6 (milo)	10	32
7 (wheat)	21	27
8 (wheat)	8.2	10
9 (wheat)	10	4.6
10 (milo)	26	22
11	11	8.2
12 (milo)	9	13
13 (milo)	10	8.8
14 (milo)	14	14
Plowed		
1	19	12
2	11	14
3	13	78
Average	14	18

[1] Each soil sample represents a composit of 4-5 surface samples (top 1-2 inches) manually collected from a given field. Analyses were performed in accordance with Recommended Chemical Soil Testing Procedures, North Central Region Publication 221, North Dakota State University, Agricultural Experiment Station, Fargo, North Dakota, February, 1975. As outlined in this publication, nitrate nitrogen was extracted using a KCL solution and phosphorus was extracted using a Na HCO_3 solution.

[2] Classification of samples marked with an asterisk is based on crops grown in 1975. Likewise crops listed in brackets under the disked category are 1975 crops.

with actively growing crops such as brome, wheat and oats were somewhat lower but a significant correlation of nutrient concentrations to land use was not apparent. No attempt was made to relate these values to fertilizer application for a particular field except for the brome field previously mentioned.

Reported herbicide and insecticide usages are presented in Tables 10-12. A limited number of runoff samples were analyzed by the U.S. Environmental Protection Agency for pesticide concentrations. However, since this was not part of this study and the number of samples analyzed were insufficient for modeling purposes, this information is not presented in this report.

Table 13 contains data obtained from base flow samples collected from Dee Creek on a weekly basis. In spite of the dry weather conditions, there was limited flow in the channel throughout the study period. Reportedly, the creek has dried up during severe drought conditions in the past. Since the control structure was not designed for accurate low (base) flow measurement, base flow rates were not determined.

Generally, concentrations of the various determinations of the base flow were relatively constant. However, significant variations were noted in some of the bacteriological data and COD (chemical oxygen demand) values. Efforts were made to detemine the cause of the variations in bacteriological data, however, these were unsuccessful. Some of the variations may be a result of previous runoff events and some high values may have resulted from the discharge of animal wastes in proximity to the stream. Some of the higher COD data probably reflect high concentrations of algae resulting from the limited water movement and other conditions conducive to plant growth.

Summaries of data for runoff events are shown in Tables 14-16. Due to incomplete data for a few events, annual runoff values were not tabulated; however, it is apparent these values were very low during the study period.

Table 10
Herbicide-Insecticide Application Data-1974
Dee Creek Watershed-Lincoln, Nebraska

Herbicides

Chemical	Crop	Acres	Amount Applied*
AAtrex	Corn	72	2.75 lb/ac
	Milo	60	2.75 lb/ac
Amiben	Soybeans	14	1 qt/ac
Atrazine	Corn	70	6 lb/ac
	Milo	60	1 lb/ac
		182	1.25 lb/ac
		17	1.5 lb/ac
		90	2 lb/ac
		95	2.5 lb/ac
Ramrod/Atrazine	Corn	45	1 lb/ac
		12	10 lb/ac
	Milo	80	1 lb/ac
		22	2 lb/ac
		142	2.5 lb/ac
		42	3 lb/ac
		25	4 lb/ac
		308	5 lb/ac
		52	6 lb/ac
		265	7 lb/ac
Lasso	Corn	22	7 lb/ac
	Soybeans	15	1 pt/ac
		7	7 lb/ac
		75	2 qt/ac
Sencor/Lasso	Soybeans	12	0.5 lb/ac
Sencor	Soybeans	88	0.5 lb/ac
		35	0.75 lb/ac
		25	2 lb/ac
		5	
Lorox	Soybeans	15	1 lb/ac
Treflan	Soybeans	84	1 pt/ac
		25	1 qt/ac
		80	1.5 qt/ac
		63	
2-4-D	Brome	67	1 pt/ac
	Corn	70	1 pt/ac
	Milo	148	0.25 pt/ac
		282	0.5 pt/ac
		3	0.67 pt/ac
		42	0.75 pt/ac
		141	1 pt/ac

Herbicide-Insecticide Application Data-1974 Cont'd

Insecticides

Chemical	Crop	Acres	Amount Applied*	
Cygon	Alfalfa	6		
	Milo	554	1	pt/ac
Di-Syston	Corn	12	7	lb/ac
	Milo	30	7	lb/ac
		257	10	lb/ac
		33		
Furadon	Corn	10		
Malathion	Milo	2	1	pt/ac
Parathion	Milo	40	1	pt/ac
		284		
Thimet	Corn	45	2	lb/ac
		22	7	lb/ac
	Milo	17	10	lb/ac

* Where values are not indicated, application rates were reported as recommended amount.

Table 11
Herbicide-Insecticide Application Data-1975
Dee Creek Watershed-Lincoln, Nebraska

Herbicides

Chemical	Crop	Acres	Amount Applied*
AAtrex	Corn	41	2.5 lb/ac
Amiben	Soybeans	12	10 lb/ac
Atrazine	Milo	115	1 lb/ac
		117	2 lb/ac
		120	
Ramrod/Atrazine	Corn	20	1 lb/ac
	Milo	90	1 lb/ac
		13	2 lb/ac
		78	3 lb/ac
		80	5 lb/ac
		133	7 lb/ac
		55	5 pt/ac
		398	
Ramrod	Milo	2	3 lb/ac
Lasso	Milo	130	1.5 qt/ac
	Soybeans	45	1.5 qt/ac
		63	2 qt/ac
Lorox	Fence rows	8	
	Soybeans	63	1.5 lb/ac
		9	
Lorox/Lasso	Soybeans	8	
	Milo	130	0.75 pt/ac
Sencor	Soybeans	45	0.75 lb/ac
		101	1 lb/ac
Lasso/Sencor	Soybeans	43	
Treflan	Soybeans	57	1 pt/ac
		56	1.5 pt/ac
		65	1 qt/ac
		18	2.5 qt/ac
		75	
Treflan/Sencor	Soybeans	45	
2-4-D	Milo	73	0.67 pt/ac
		143	1 pt/ac
		485	

Insecticides

Chemical	Crop	Acres	Amount Applied*
Cygon	Milo	40	0.75 pt/ac
		286	1 pt/ac
		735	
Di-Syston	Milo	95	7 lb/ac

Herbicide-Insecticide Application Data-1975 Cont'd

Insecticides

Chemical	Crop	Acres	Amount Applied*
		73	
Malathion	Alfalfa	12	
Parathion	Milo	370	
Thimet	Corn	20	3 lb/ac

* Where values are not indicated, application rates were reported as recommended amount.

Table 12
Herbicide-Insecticide Application Data-1976
Dee Creek Watershed-Lincoln, Nebraska

Herbicides

Chemical	Crop	Acres	Amount Applied *
Amiben	Soybeans	15	
Atrazine	Corn	5	2 lb/ac
		11	2.75 lb/ac
	Milo	162	1 lb/ac
		117	2 lb/ac
		137	
Ramrod/Atrazine	Corn	20	1 lb/ac
		35	
	Milo	90	1 lb/ac
		221	
Ramrod	Corn	12	10 lb/ac
	Milo	279	1.5 lb/ac
		14	3 lb/ac
		240	4 lb/ac
		104	5 lb/ac
		242	
Cobex	Soybeans	36	
Lasso/Lorox	Soybeans	22	
Lasso/Sencor	Soybeans	14	
Sencor	Soybeans	35	
Treflan/Lorox	Soybeans	23	
Treflan	Soybeans	57	1 pt/ac
		55	1 qt/ac
		35	
2-4-D	Corn	12	
	Milo	360	

Insecticides

Chemical	Crop	Acres	Amount Applied*
Cygon	Milo	102	1 pt/ac
		544	
Di-Syston	Corn	12	
	Milo	73	
Furadan	Corn	16	5 lb/ac
Parathion	Milo	1126	
Thimet	Corn	20	3 lb/ac
	Milo	66	

* Where values are not indicated, application rates were reported as recommended amount.

Table 13
Analyses of Base Flow Samples
Dee Creek Watershed-Lincoln, Nebraska

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
1-14-74	490	8.4			0.07	4.0	0.28	40	2	200
1-21-74	590	8.5			0.05	3.8	0.19	40	5	260
1-28-74	520	8.4			0.07	3.8	0.24	36	6	225
2-4-74	560	8.4			0.08	4.9	0.08	45	3	240
2-11-74	540	8.4			0.30	4.7	0.08	42	3	230
2-18-74	580	8.5	5	11.1	0.17	3.4	0.15	44		260
2-25-74	640	8.5			0.07	4.9	0.17	47		300
3-4-74	600	8.5			0.14	3.4	-	42	3	270
3-11-74	570	8.4	7	14.0	0.11	3.5	0.49	44		245
3-18-74	550	8.4	5	15.0	0.18	3.3	0.06	47		235
3-25-74	560	8.4	1	14.0	0.08	3.9	0.10	43	9	240
4-1-74	520	8.4	15	17.0	0.16	2.4	0.10	43	3	230
4-8-74	520	8.4	7	15.7	0.12	2.6	0.09	42	13	235
4-15-74	590	8.5	6	12.8	0.24	3.4	0.19	41	6	265
4-29-74	490	8.3	12		1.40	3.4	0.45	35		200
5-7-74	640	8.5	8		0.05	4.0	0.24	43	6	280
5-13-74	620	8.5			0.08	4.3	0.24	42	5	300
5-20-74	610	8.5			0.09	4.0	0.28	41	6	290
5-27-74	620	8.5			0.10	4.0	0.29	42	4	295
6-3-74	590	8.5			0.10	4.6	0.24	48		295
6-10-74	590	8.5			0.07	4.3	0.21	48		295

Table 13
Analyses of Base Flow Samples
Dee Creek Watershed-Lincoln, Nebraska

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
1-14-74			460	60	
1-21-74			23,000	140	
1-28-74			640		
2-4-74			4,900		
2-11-74			4,600	20	
2-18-74			4,900	90	
2-25-74			4,600	140	
3-4-74			2,300	80	
3-11-74			1,300	130	
3-18-74			1,100	130	
3-25-74			950	130	
4-1-74			790	130	
4-8-74			2,200	20	
4-15-74			24,000	13,000	
4-29-74			1,300,000	240,000	
5-7-74			17,000	3,300	5,600
5-13-74			1,300,000	9,500	6,600
5-20-74			130,000	79,000	5,400
5-27-74			49,000	7,900	1,400
6-3-74			13,000	7,900	-
6-10-74			49,000	7,900	8,300

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
6-17-74	620	8.5			0.09	4.5	0.25	40	4	295
6-24-74	580	8.6			0.12	4.4	0.18	41	8	270
7-1-74	570	8.5			0.24	4.6	0.28	39	4	260
7-8-74	560	8.5			0.36	4.6	0.30	43		255
7-15-74	570	8.4			0.33	5.3	0.38	42		240
7-22-74	550	8.4			0.52	5.4	0.35	42		245
7-29-74	550	8.3			0.44	4.9	0.30	43	5	255
8-5-74	560	8.2			0.15	4.4	0.11	41	4	245
8-12-74	570	8.4			0.13	4.4	0.38	48		240
8-19-74	560	8.4			0.18	4.2	0.36	43		255
9-3-74	600	8.3			0.19	3.8	0.29	42	5	245
9-9-74	590	8.4			0.25	4.2	0.29	40	6	265
9-16-74	610	8.2			-	4.3	0.33	39	8	245
9-23-74	540	8.5			1.8	3.0	0.30	44		315
9-30-74	540	8.4			0.03	4.0	0.33	40	6	315
10-7-74	540	8.4			0.19	-	0.35	41	11	320
10-14-74	550	8.3			0.05	2.6	0.29	41	6	335
10-21-74	560	8.4			0.12	2.7	0.33	43	10	335
10-28-74	550	8.4			0.05	2.1	0.29	42		345
11-4-74	540	8.2	5	10.6	0.04	7.9	0.14	41	10	320
11-11-74	570	8.4	0	14.2	0.07	9.9	0.11	44	5	345
11-18-74	600	8.5	5	12.4	0.22	2.8	0.22	42	3	340
11-25-74	580	8.6	-	-	0.43	3.8	0.26	43	3	345
12-2-74	600	8.6	0	13.0	0.10	3.9	0.21	44	3	350

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
6-17-74			130,000	1,100	2,200
6-24-74	0		170,000	45	2,800
7-1-74	0		4,900	1,300	1,000
7-8-74	0		22,000	1,100	1,000
7-15-74	6		22,000	2,300	820
7-22-74	0		33,000	2,800	4,900
7-29-74	0		130,000	700	490
8-5-74	13		350,000	3,500	650
8-12-74	13		79,000	17,000	-
8-19-74	38		28,000	2,300	3,300
9-3-74	38		9,200	170	120
9-9-74	38		23,000	270	1,400
9-16-74	42		130,000	490	1,000
9-23-74	42		230,000	790	2,200
9-30-74	33		23,000	490	380
10-7-74	46		49,000	790	600
10-14-74	54		49,000	330	420
10-21-74	38		330	130	370
10-28-74	29		7,900	230	530
11-4-74			33,000	4,900	5,900
11-11-74	14		3,300	220	570
11-18-74	9		22,000	-	500
11-25-74	9		33,000	330	600
12-2-74	-		4,900	490	730

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
12-9-74	610	8.6	0	10.6	0.12	4.2	0.21	45	5	375
12-16-74	550	8.3	0	11.2	0.11	1.9	0.10	42	3	330
1-6-75	560	8.5	1	12.4	0.13	3.3	0.18	41	3	335
1-13-75	570	8.3	0	13.6	0.22	3.8	0.10	41	4	325
1-20-75	550	8.4	1	12.8	0.25	3.1	0.20	38	3	315
1-27-75	540	8.4	-	-	0.21	3.1	0.21	39	3	310
2-3-75	540	8.2	1	14.0	-	-	0.19	40	3	315
2-10-75	580	8.3	0	13.6	0.15	3.4	0.19	40	2	275
2-17-75	580	8.2	2	14.2	0.16	2.6	0.11	38	2	265
2-24-75	570	8.3	-	-	0.15	3.2	0.16	39	3	270
3-3-75	580	8.3	2	14.2	0.14	3.2	0.19	39	5	270
3-12-75	580	8.2	-	-	0.14	3.0	0.18	40	3	275
3-17-75	280	7.9	-	-	0.18	3.2	0.25	15	9	100
3-31-75	620	8.0	11	11.2	0.13	3.4	0.18	42	4	275
4-7-75	610	8.3	-	-	0.12	2.8	0.18	40	3	270
4-14-75	580	8.3	15	16.0	0.13	2.2	0.11	41	4	260
4-21-75	570	8.3	18	16.8	0.20	1.2	0.14	42	3	250
4-28-75	580	8.3	-	-	0.20	2.0	0.20	30	9	280
5-4-75	540	8.2	24	17.4	0.50	1.5	0.14	42	3	260
5-12-75	580	8.2	20	13.8	0.17	2.8	0.30	41	4	285
5-20-75	560	8.2	22	9.4	0.28	2.5	0.30	41	4	280
5-27-75	560	8.3	13	9.0	0.14	2.5	0.30	40	2	280
6-2-75	570	8.2	-	-	0.14	2.4	0.30	40	10	285

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
12-9-74	9		11,000	490	1,100
12-16-74	9		7,000	-	600
1-6-75	14		17,000	490	280
1-13-75	9		13,000	460	700
1-20-75	9		13,000	230	500
1-27-75	14		3,300	80	250
2-3-75	32		4,900	330	420
2-10-75	4		7,000	140	160
2-17-75	4		9,000	-	300
2-24-75	4		2,300	20	280
3-3-75	4		130,000	140	3,180
3-12-75	8		13,000	-	150
3-17-75	43		350,000	790	28,600
3-31-75			3,300	40	320
4-7-75			17,000	78	610
4-14-75			79,000	170	730
4-21-75			1,700	68	150
4-28-75			7,900	5,400	1,120
5-4-75			3,300	-	60
5-12-75			3,300	110	1,000
5-20-75			-	-	-
5-27-75			3,500	170	1,000
6-2-75			17,000	1,700	1,200

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
6-17-75	580	7.7	26	8.1	0.15	2.3	0.18	43	5	285
6-23-75	570	7.9	18		0.17	3.0	0.30	40	5	280
6-30-75	-		22							
7-7-75	570	7.8	20		0.26	2.7	0.44	39	4	275
7-14-75	610	8.3	16		0.08	3.2	0.30	40	5	270
7-21-75	610	8.3	19		0.05	3.8	0.40	38	4	260
7-28-75	600	8.2	21		0.05	4.0	0.39	39	3	265
8-4-75	600	8.0	21		0.04	3.7	0.42	38	3	260
8-11-75	580	8.1	22		0.04	4.0	0.45	38	3	250
8-18-75	580	8.1	20		0.08	3.8	0.48	39	4	260
8-25-75	560	8.1	21		0.39	3.7	0.43	40	6	250
9-2-75	560	7.9	25		0.07	3.6	0.46	39	4	255
9-8-75	580	7.8	14	10.0	0.21	3.8	0.49	41		255
9-15-75	580	7.7			0.09	3.9	0.40	38	12	250
9-22-75	590	7.7	10		0.07	4.0	0.47	38	5	260
9-29-75	480	8.0	14		0.10	4.0	0.37	38	4	255
10-6-75	500	8.1	11		0.10	3.7	0.45	38	4	260
10-13-75	480	8.1			0.07	1.2	0.20	39	5	275
10-20-75	480	8.2			0.07	3.2	0.41	38	4	270
10-27-75	470	8.1			0.06	3.3	0.42	39	9	270
11-3-75	480	8.2			0.07	2.6	0.38	40	5	285
11-10-75	520	8.1			0.09	2.6	0.53	43	13	270
11-17-75	490	7.7			0.11	1.4	0.11	41	4	275
11-24-75	510	8.2			0.13	2.9	0.31	42	4	285

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
6-17-75			1,100	230	1,200
6-23-75			3,300	110	4,500
6-30-75					
7-7-75		2	23,000	4,900	2,500
7-14-75	9	2	7,900	140	2,000
7-21-75	12	2	13,000	93	2,200
7-28-75	11	2	130,000	790	2,500
8-4-75		2	130,000	330	2,000
8-11-75		2	23,000	210	1,800
8-18-75			49,000	330	1,800
8-25-75			33,000	330	2,100
9-2-75					
9-8-75			23,000	170	1,300
9-15-75					600
9-22-75		1	79,000	260	600
9-29-75		2	33,000	2,800	700
10-6-75				170	1,300
10-13-75			13,000	130	1,200
10-20-75			54,000	80	600
10-27-75			10,900	80	600
11-3-75				20	500
11-10-75			70,000	1,720	10,800
11-17-75			2,400	50	325
11-24-75			18,000	1,200	1,270

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
12-1-75	510	8.2			0.07	3.1	0.30	44	7	280
12-8-75	470	8.1			0.11	2.2	0.21	40	3	270
12-15-75	550	8.2			0.14	3.1	0.28	46	4	310
12-22-75	510	8.2			0.07	2.8	0.19	43	3	300
12-29-75	470	8.1			0.11	2.6	0.16	39	2	270
1-5-76	550	8.1			0.05	4.3	0.27	46	2	330
1-11-76	550	8.0			0.14	3.6	0.23	46	3	315
1-19-76	490	8.0	0	12.2	0.10	2.8	0.17	39	2	275
1-26-76	480	8.1	1	12.1	0.11	2.8	0.16	39	2	280
2-2-76	470	7.9	0	13.2	0.13	2.7	0.15	38	2	265
2-9-76	460	7.7	0	14.0	-	-	0.13	35	2	
2-16-76	490	8.3	2	12.4	0.06	2.2	0.21	33	3	250
2-23-76	540	8.5	0	14.2	0.05	2.3	0.22	40	5	
3-1-76	550	8.3	1	12.8	0.07	1.7	0.13	41	3	
3-8-76	520	8.3	1	14.3	0.08	1.8	0.14	36	3	
3-15-76	530	8.4	1	13.6	0.08	1.4	0.13	39	3	
3-22-76	510	8.2	6	12.5	0.07	0.91	0.12	40	3	
3-29-76	520	8.2	9	9.0	0.08	0.80	0.12	40	3	
4-5-76	530	8.3	8	10.8	0.10	0.78	0.12	42	3	
4-12-76	480	8.5	9	13.4	0.09	0.85	0.18	41	3	
4-19-76	-		12	10.0	0.25	1.4	0.27	41	5	
4-26-76	-	8.0	8	10.1	0.37	2.1	0.27	42	5	295
5-3-76	630	8.0	8	10.6	0.05	2.0	0.24	41	3	305
5-10-76	590	8.1	13	7.6	0.07	1.3	0.21	41	3	275

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
12-1-75			4,900	170	3,700
12-8-75			27,800	-	700
12-15-75			7,000	50	600
12-22-75			1,300	45	240
12-29-75			2,200	20	140
1-5-76					
1-11-76			2,300	20	140
1-19-76		2	3,300	40	300
1-26-76		4	2,300	<20	730
2-2-76			230	<20	140
2-9-76		2	490	20	220
2-16-76		3	3,800	90	2,500
2-23-76		3	2,200	75	500
3-1-76		2	4,900	110	140
3-8-76		3	1,500	250	1,800
3-15-76		3	1,700	25	150
3-22-76		3	2,600	110	1,000
3-29-76		2	49,000	1,100	390
4-5-76		2	1,400	170	320
4-12-76		2	33,000	170	280
4-19-76		1	33,000	790	1,800
4-26-76		3	3,300,000	63,000	7,600
5-3-76			4,600	230	1,200
5-10-76		3			

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
5-17-76		8.1	11	11.0	0.21	2.7	0.27	39	7	270
5-24-76		8.1	13	9.6	0.33	2.2	0.25	40	7	285
6-1-76		8.0			0.14	1.7	0.28	41	3	300
6-7-76	550	8.5			0.06	2.3	0.31	40	3	
6-14-76	520	8.4			0.06	2.6	0.34	39	3	
6-21-76	510	8.5			0.05*	2.5	0.30	38	3	
6-28-76	520	8.5			0.07	3.7	0.34	37	3	
7-6-76	510	8.4			0.07	4.5	0.30	38	3	
7-13-76	-									
7-19-76	490	8.4			0.10	2.4	0.38	37	3	
7-28-76	500	7.4			0.08	2.3	0.42	36	6	
8-2-76	500	8.2			0.06	2.3	0.40	37	4	265
8-16-76	450	8.1			0.10	2.4	1.1	34	14	185
8-23-76	540	8.2			0.06	0.93	0.47	39	6	270
9-7-76	480	8.2			0.06	0.54	0.47	38	5	270
9-13-76	490	8.1			0.33	0.43	0.31	38	5	265
9-20-76	300	7.7			1.1	3.2				57
10-4-76	540				0.25	0.59				
10-11-76	520						0.22	41	8	
10-18-76	530	8.5			0.16	1.1	0.27	41	8	
11-1-76	550	8.5			0.20	1.7	0.18	42	8	200
11-8-76	560	8.3			0.15	1.8	0.20	44	8	280

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
5-17-76					
5-24-76					
6-1-76					
6-7-76					
6-14-76					
6-21-76					
6-28-76					
7-6-76					
7-13-76					
7-19-76		2			
7-28-76		3			
8-2-76					
8-16-76		4			
8-23-76		5			
9-7-76		3			
9-13-76					
9-20-76		8			
10-4-76					
10-11-76					
10-18-76		2			
11-1-76		1			
11-8-76					

Analyses of Base Flow Samples Cont'd

Date	Conduct umhos/cm	pH	Temp., °C	DO, mg/l	NH_3-N mg/l	NO_3-N mg/l	Inorg. P mg/l-P	Na mg/l	K mg/l	Hardness mg/l as $CaCO_3$
11-22-76	550	8.5			0.06	1.8	0.21	41	5	265
11-25-76	570	8.5			0.09	1.8	0.27	43	8	290
11-30-76	690	8.4			0.13	2.1	0.21	46	5	305
12-6-76	670	8.3			0.17	3.6	0.21	44	5	300
12-13-76	720	8.4			0.13	3.2	0.22	49	6	290
12-20-76	680	8.4			0.09	1.8		44	6	290
12-27-76	670	8.3			0.13	2.2		43	4	290
1-10-77	720	8.3			0.23	3.3		42	4	290

Analyses of Base Flow Samples Cont'd

Date	COD mg/l	BOD mg/l	Total Coliform per 100 ml	Fecal Coliform per 100 ml	Fecal Strep. per 100 ml
11-22-76					
11-25-76					
11-30-76					
12-6-76					
12-13-76					
12-20-76					
12-27-76					
1-10-77					

Table 14
Summation of Data from Runoff Events - July through December, 1974[1]
Dee Creek Watershed - Lincoln, Nebraska

Date of Event[2]	August 16
Runoff	
cu ft	810,000
equiv. depth over watershed, in	0.045
max. rate, cfs	70
sampled flow[3], cu ft	850,000
Total Solids	
tons	49
tons/acre	0.010
range in concentrations, mg/l	240-6200
ave. concentration, mg/l	1850
Inert Solids	
tons	-
tons/acre	-
range in concentrations, mg/l	-
ave. concentration, mg/l	-
Volatile Solids	
tons	-
tons/acre	-
range in concentrations, mg/l	-
ave. concentration, mg/l	-
Nitrogen as N	
Sediment	
lbs	340
lbs/acre	0.68
range in concentration, ppm	1,500-4,000
ave. concentration, ppm	3470
Dissolved	
Ammonia	
lbs	16
lbs/acre	.300
range in concentration, mg/l	0.11-0.65
ave. concentration, mg/l	0.30
Nitrate	
lbs	170
lbs/acre	0.34
range in concentration, mg/l	1.6-3.9
ave. concentration, mg/l	3.2

Summation Data July through December, 1974[1] Cont'd

Phosphorus as P	
Sediment	
lbs	43
lbs/acre	0.009
range in concentration, ppm	210-500
ave. concentration, ppm	440
Dissolved Inorganic	
lbs	19
lbs/acre	0.004
range in concentration mg/l	0.11-0.50
ave. concentration, mg/l	0.36
Potassium	
lbs	900
lbs/acre	0.18
range in concentration, mg/l	5-29
ave. concentration, mg/l	17
Sodium	
lbs	1500
lbs/acre	0.30
range in concentration, mg/l	20-41
ave. concentration, mg/l	28
Chemical Oxygen Demand	
lbs	7200
lbs/acre	1.4
range in concentration, mg/l	4-340
ave. concentration, mg/l	135

[1]During the study period, precipitation on the watershed was considerably below normal. Therefore, these data should not be considered representative of runoff during normal weather conditions.

[2]A runoff event was assumed to occur when the depth of flow in the creek at the control structure increased sufficiently above base flow to start the sampling equipment (0.3 foot).

[3]Sampled flow values represent the quantity of water passing the gauging station during the period of sampling. Base flows were subtracted from these values to obtain the runoff volumes. Because concentrations of parameters such as suspended solids and associated components are minimal under base flow concitions, sampled flow values were used for calculating quantities and average concentrations of constituents in the runoff.

Table 15
Summation of Data from Runoff Events - 1975[1]
Dee Creek Watershed-Lincoln, Nebraska

Date of Event[2]	March 18	March 19	March 20	March 27	April 23
Runoff					
cu ft	2,600,000	2,500.000	110,000	820,000	230,000
equiv. depth over watershed, in	0.14	0.14	0.006	0.045	0.013
max. rate cfs	140	140	45	60	17
sampled flow[3], cu ft	3,200,000	3,100,000	1,000,000	1,300,000	140,000
Total Solids					
tons	391	342	34.9	79.5	-
tons/acre	0.078	0.068	0.007	0.016	-
range in concentrations, mg/l	240-6700	220-5600	380-1900	650-2500	-
ave. concentration, mg/l	3900	3500	1100	2000	
Inert Solids					
tons	359	311	31	70.3	-
tons/acre	.072	.062	.006	.014	-
range in concentrations, mg/l	180-6200	130-5100	270-1700	530-2300	-
ave. concentration, mg/l	3600	3200	990	1700	-
Volatile Solids					
tons	32	31	3.9	9.2	-
tons/acre	.006	.006	.0008	.002	-
range in concentrations, mg/l	4-500	99-490	40-190	130-260	-
ave. concentration, mg/l	320	320	120	220	-
Nitrogen as N					
Sediment					
lbs	1280	935	135	325	-
lbs/acre	0.26	0.19	0.027	0.065	-
range in concentration, ppm	1300-4400	1100-3500	1600-2800	1600-3200	-
ave. concentration, ppm	1600	1400	1900	2000	
Dissolved					
Ammonia					
lbs	36	32	3.7	7.5	-
lbs/acre	0.007	0.006	0.001	0.002	-
range in concentration mg/l	0.14-0.54	0.01-1.2	0.05-0.09	0.01-0.20	0.13-0.23
ave. concentration, mg/l	0.18	0.17	0.06	0.09	
Nitrate					
lbs	532	500	167	278	
lbs/acre	0.11	0.10	0.033	0.056	
range in concentration mg/l	2.1-3.3	2.0-3.6	2.3-3.7	2.6-4.3	1.6-3.0
ave. concentration, mg/l	2.7	2.8	2.7	3.4	

Summation of Data from Runoff Event - 1975[1] Cont'd

Date of Event[2]	March 18	March 19	March 20	March 27	April 23
Phosphorus as P					
Sediment					
lbs	165	135	15	46	-
lbs/acre	0.033	0.027	.003	0.009	
range in concentration, ppm	180-330	65-280	70-330	120-440	-
ave. concentration, ppm	210	200	210	290	
Dissolved Inorganic					
lbs	55	33	11	27	
lbs/acre	0.011	0.007	0.002	0.005	
range in concentration mg/l	0.07-0.51	0.08-0.25	0.15-0.22	0.19-0.36	0.07-0.24
ave concentration, mg/l	0.28	0.17	0.18	0.33	
Potassium					
lbs	1740	1700	470	760	
lbs/acre	0.35	0.34	0.094	0.15	
range in concentration, mg/l	8-11	7-22	7-8	5-10	3-10
ave. concentration, mg/l	9	9	8	9	
Sodium					
lbs	2160	2320	1200	1480	
lbs/acre	0.43	0.46	0.24	0.30	
range in concentration, mg/l	8-19	8-26	15-30	15-31	30-39
ave. concentration, mg/l	11	12	19	18	
Chemical Oxygen Demand					
lbs.	77,000	35,800	3700	9920	-
lbs/acre	15	7.2	0.74	2.0	-
range in concentration mg/l	15-1170	31-285	16-135	45-170	-
ave. concentration, mg/l	385	185	60	120	

[1]During the study period, precipitation on the watershed was considerably below normal. Therefore, these data should not be considered representative of runoff during normal weather conditions.

[2]During 1975 and 1976, the equipment was adjusted to commence sampling when the depth of flow in the creek increased 0.2 foot above base flow conditions.

[3]Due to malfunction of equipment, sampling data are incomplete for this runoff event.

[4]Sampled flow values represent the quantity of water passing the gauging station during the period of sampling. Base flows were subtracted from these values to obtain the runoff volumes. Because concentrations of parameters such as suspended solids and associated components are minimal under base flow conditions, sampled flow values were used for calculating quantities and average concentrations of constituents in the runoff.

Summation of Data from Runoff Event - 1975[1] Cont'd

Date of Event[2]	May 27	June 2	June 8	June 18	June 25
Runoff					
cu ft	130,000	1,000,000	750,000	1,800,000	170,000
equiv. depth over watershed, in	0.007	0.059	0.041	0.098	0.009
max. rate cfs	8	110	75	200	10
Sampled flow[3], cu ft	70,000	1,100,000	810,000	1,800,000	140,000
Total Solids					
tons	1.5	233	134	283	6.8
tons/acre	0.0003	0.046	0.027	0.056	0.001
range in concentrations, mg/l	470-880	380-11,000	250-8,100	280-8000	240-3100
ave. concentration, mg/l	690	6800	5300	5000	1600
Inert Solids					
ton	-	206	118	251	5.9
ton/acre	-	0.041	0.024	0.050	0.001
range in concentration, mg/l	-	300-9,600	190-7,200	200-7200	160-2700
ave. concentration, mg/l	-	6000	4700	4500	1400
Volatile Solids					
ton	-	27	16	32	0.9
tons/acre	-	0.005	0.003	0.006	Nil
range in concentration, mg/l	-	80-1200	60-860	70-820	70-400
ave. concentration, mg/l	-	790	630	570	210
Nitrogen as N					
Sediment					
lbs	7.1	832	475	1040	29.1
lbs/acre	0.001	0.17	0.095	0.21	0.006
range in concentration, ppm	2,200-2,500	1,300-2500	700-2,600	1,000-2600	2000-2500
ave. concentration, ppm	2400	1800	1800	1800	2100
Dissolved					
Ammonia					
lbs	1.8	23	11	38	2.4
lbs/acre	Nil	0.005	0.002	0.008	Nil
range in concentration, mg/l	0.23-1.1	0.16-0.98	0.12-0.52	0.13-0.47	0.13-3.7
ave. concentration, mg/l	0.41	0.34	0.22	0.34	0.27
Nitrate					
lbs	6.6	250	152	232	24.7
lbs/acre	0.001	.050	0.030	0.046	0.005
range in concentration, mg/l	1.3-1.8	2.0-4.6	2.6-3.9	1.2-2.6	2.1-3.6
ave. concentration, mg/l	1.5	3.6	3.0	2.1	2.8
Phosphorus as P					
Sediment					
lbs	0.3	43	29	67	2
lbs/acre	Nil	0.009	0.006	0.013	Nil
range in concentration, ppm	25-200	17-150	31-170	49-370	36-190
ave. concentration, ppm	100	90	110	120	150

Summation of Data from Runoff Event - 1975[1] Cont'd

Date of Event[2]	May 27	June 2	June 8	June 18	June 25
Dissolved Inorganic					
lbs	0.8	5.9	4.6	14	1.5
lbs/acre	Nil	0.001	0.001	0.003	Nil
range in concentration, mg/l	0.17-0.24	0.04-0.28	0.05-0.28	0.08-0.25	0.13-0.24
ave. concentration, mg/l	0.18	0.09	0.09	0.12	0.17
Potassium					
lbs	24	600	450	990	68
lbs/acre	0.005	0.12	0.09	0.20	0.014
range in concentration, mg/l	4-11	6-10	6-16	5-15	6-13
ave. concentration, mg/l	5	9	9	9	8
Sodium					
lbs	139	1100	735	1270	264
lbs/acre	0.028	0.22	0.15	0.25	0.053
range in concentration, mg/l	32-35	10-36	8-33	6-35	18-38
ave. concentration, mg/l	32	16	15	11	30
Chemical Oxygen Demand					
lbs	146	34,700	20,200	40,400	935
lbs/acre	0.03	6.9	4.0	8.1	0.19
range in concentration, mg/l	0.0-59	26-770	21-550	39-510	21-230
ave. concentration, mg/l	33	510	400	360	110

Table 16
Summation of Data from Runoff Event - 1976[1]
Dee creek Watershed-Lincoln, Nebraska

Date of Event[2]	March 29[3]	April 6[3]	April 15	April 24	April 27
Runoff					
cu ft	630,000	110,000	180,000	340,000	1,000,000
equiv. depth over watershed in	0.035	0.006	0.010	0.019	0.055
max. rate cfs	19	6.5	17	9.5	100
sampled flow, cu ft			200,000	210,000	1,100,000
Total Solids					
tons			30.6	6.8	152
tons/acre			0.006	0.001	0.030
range in concentrations, mg/l			280-9100	370-1400	560-6000
ave. concentration, mg/l			4900	1040	4400
Inert Solids					
tons			26.5	5.6	132
tons/acre			0.005	0.001	0.026
range in concentrations, mg/l			210-8000	260-1200	460-5300
ave. concentration, mg/l			4200	850	3800
Volatile Solids					
tons			4.1	1.2	20
tons/acre			0.001	Nil	0.004
range in concentrations, mg/l			76-1100	78-240	50-710
ave. concentration, mg/l			650	200	600
Nitrogen as N					
Sediment					
lbs			168	67	790
lbs/acre			0.034	0.013	0.16
range in concentration ppm			2300-3300	3400-7000	2000-3600
ave. concentration, ppm			2740	4900	2600
Dissolved					
Ammonia					
lbs			6.5	6.5	42
lbs/acre			0.001	0.001	0.008
range in concentration, mg/l			0.13-0.86	0.15-0.66	0.26-1.2
ave. concentration, mg/l			0.52	0.50	0.61
Nitrate					
lbs			15	24	134
lbs/acre			0.003	0.005	0.027
range in concentration, mg/l			0.74-1.9	1.1-2.8	0.98-3.4
ave. concentration, mg/l			1.2	1.8	2.0
Phosphorus as P					
Sediment					
lbs			9.2	6.2	61
lbs/acre			0.002	0.001	0.012
range in concentration, ppm			21-210	25-770	19-360
ave. concentration, ppm			150	450	200

Summation of Data from Runoff Event - 1976[1] Cont'd

Date of Event[2]	March 29[3]	April 6[3]	April 15	April 24	April 27
Dissolved Inorganic					
lbs			2.1	6.9	11
lbs/acre			Nil	0.001	0.002
range in concentration, mg/l			0.06-0.28	0.13-0.92	0.09-0.33
ave. concentration, mg/l			0.17	0.53	0.16
Potassium					
lbs			99	150	520
lbs/acre			0.20	0.30	0.10
range in concentration, mg/l				6-14	5-10
ave. concentration, mg/l			8	11	8
Sodium					
lbs			330	389	990
lbs/acre			0.066	0.078	0.20
range in concentration, mg/l			14-42	27-33	9-37
ave. concentration, mg/l			26	30	14
Chemical Oxygen Demand					
lbs			5030	1180	34,700
lbs/acre			1.0	0.24	6.9
range in concentration, mg/l			25-700	16-160	130-620
ave. concentration, mg/l			400	90	500

[1]During the study period, precipitation of the watershed was considerably below normal. Therefore, these data should not be considered representative of runoff during normal weather conditions.

[2]During 1975 and 1976, the equipment was adjusted to commence sumpling when the depth of flow in the creek increased 0.2 foot above base flow conditions.

[3]Due to malfunction of equipment, these events were not sampled.

Summation of Data from Runoff Event - 1976[1]

Date of Event[2]	May 22	May 23	Sept 19	Sept 25
Runoff				
cu ft	460,000	1,400,000	180,000	100,000
equiv. depth over watershed in	0.025	0.077	0.010	0.006
max. rate, cfs	47	150	9.8	7.8
sampled flow, cu ft	520,000	1,700,000	150,000	90,000
Total Solids				
tons	80	295	6.5	5.1
tons/acre	0.016	.059	.001	.001
range in concentrations, mg/l	140-7500	1400-10,700	370-2800	0-9500
ave. concentration, mg/l	4900	5600	1400	1800
Inert Solids				
tons	68	261		
tons/acre	0.014	0.050		
range in concentrations, mg/l	80-6500	1200-9200		
ave. concentrations, mg/l	4200	4920		
Volatile Solids				
tons	12	34		
tons/acre	0.002	0.007		
range in concentrations, mg/l	60-1100	250-1500		
ave. concentration, mg/l	700	640		
Nitrogen as N				
Sediment				
lbs	420	1820	42	47
lbs/acre	0.084	0.36	0.008	0.009
range in concentration ppm	2200-4900	2600-4900	2800-4200	3600-5000
ave. concentration, ppm	2600	3100	3200	4600
Dissolved				
Ammonia				
lbs	15	48	2.3	1.4
lbs/acre	0.003	0.010	Nil	Nil
range in concentration mg/l	0.17-0.70	0.33-0.53	0.08-1.1	0.10-0.74
ave. concentration, mg/l	0.46	0.45	0.25	0.25
Nitrate				
lbs	65	405	15	8.6
lbs/acre	0.013	0.081	0.003	0.002
range in concentration mg/l	1.1-3.7	2.2-4.8	0.6-4.0	1.2-2.8
ave. concentration, mg/l	2.0	3.8	1.6	1.5
Phosphorus as P				
Sediment				
lbs	26	93	4.1	5.9
lbs/acre	0.005	0.019	0.001	0.001
range in concentration ppm	53-280	98-240	280-380	500-620
ave. concentration, ppm	160	160	320	580

Summation of Data from Runoff Event - 1976 Cont'd

Date of Event	May 22	May 23	Sept 19	Sept 25
Dissolved Inorganic				
lbs	5.0	26	5.4	2.7
lbs/acre	0.001	0.005	0.001	Nil
range in concentration mg/l	0.09-0.35	0.12-0.47	0.27-0.68	0.41-0.62
ave. concentration, mg/l	0.15	0.25	0.58	0.48
Potassium				
lbs	315	1220	90	66
lbs/acre	0.063	0.24	0.018	0.013
range in concentration mg/l	6-13	9-13	6-18	10-16
ave. concentration, mg/l	10	12	7	12
Sodium				
lbs	515	1210	410	123
lbs/acre	0.10	0.24	0.08	0.025
range in concentration mg/l	10-22	7-29	20-38	19-25
ave. concentration, mg/l	16	11	34	22
Chemical Oxygen Demand				
lbs	13,400	48,800	279	
lbs/acre	2.7	9.8	0.056	
range in concentration mg/l	35-600	140-830	14-210	
ave. concentration, mg/l	415	460	50	

Based on data presented in Table 8, approximately 30 percent of the dissolved nitrogen in the runoff could be due to the nitrogen present in the precipitation. In the 30 month study period, runoff was recorded during nine months. Recorded monthly runoff values and associated total solids are presented below:

Month	Runoff, inches	Total Solids, tons/acre
August, 1974	0.045	0.01
March, 1975	0.33	0.17
April, 1975	0.013	NA
May, 1975	0.007	0.0003
June, 1975	0.21	0.13
March, 1976	0.035	NA
April, 1976	0.090	$\leq$ 0.04
May, 1976	0.10	0.075
September, 1976	0.016	0.002

Figures 8-10 show the hydrograph and associated sediment and nutrient transport for one of the major recorded runoff events, June 18, 1975. As expected, the rate of movement or loss of the various components from the watershed is related to the rate of runoff. Since soils transport is dependent upon runoff rates, this general relationship exists whether the compound is dissolved in the water or adsorbed to the transported solids.

The simulated hydrograph obtained for this runoff event for one of the runs using the ARM Model is also included in Figure 8. The relationships between recorded and simulated hydrographs are discussed in the section of this report on calibration and evaluation of runoff simulation models.

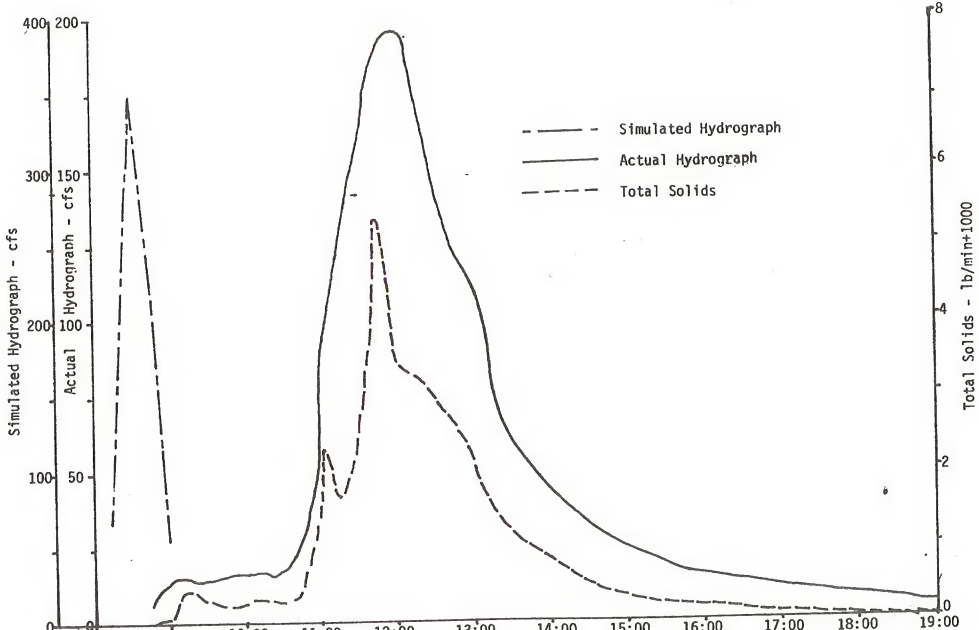


Figure 8: June 18, 1975 Storm Runoff, Dee Creek Watershed, Lincoln, Nebraska

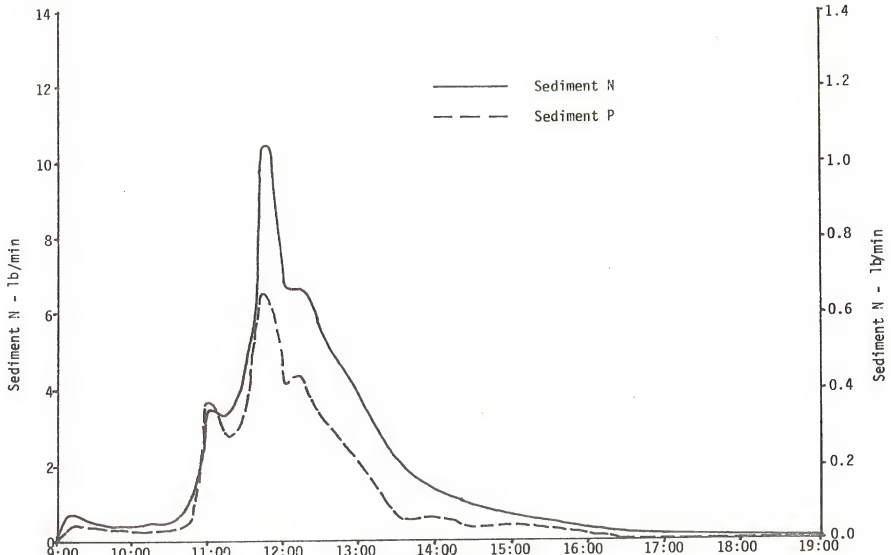


Figure 9: June 18, 1975 Storm Runoff, Dee Creek Watershed, Lincoln,Nebraska

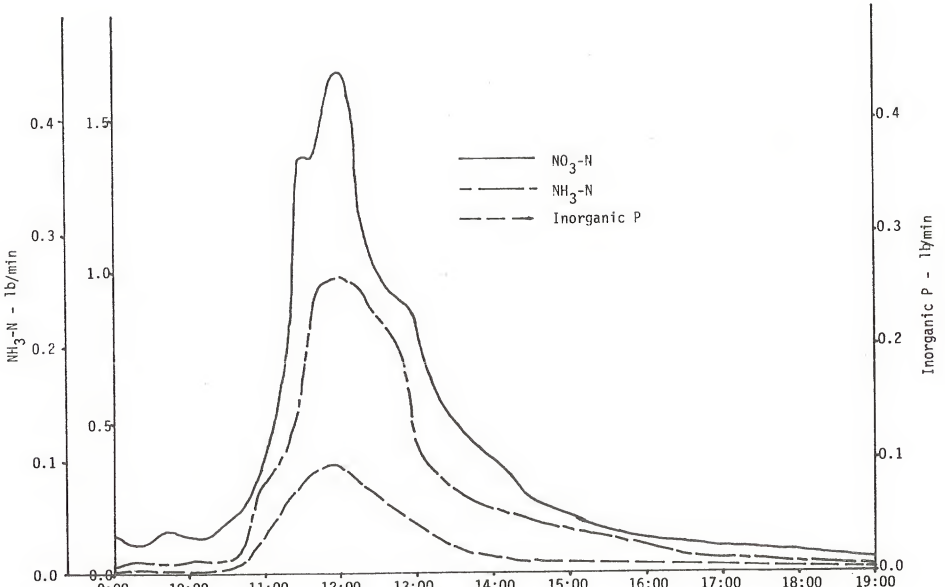


Figure 10: June 18, 1975 Storm Runoff, Dee Creek Watershed, Lincoln, Nebraska

V. DISCUSSION AND EVALUATION OF RUNOFF SIMULATION MODELS

The Federal Water Pollution Control Act Amendments of 1972 requires that the significance of nonpoint waste discharges on water quality be evaluated. Because of the numerous variables involved, this is an extremely difficult task. One approach which is showing some promise in evaluating the impact of these discharges is the use of mathematical models. These models attempt to simulate the complex physical processes involved through the use of mathematical functions.

While considerable effort has gone into the development of these models, additional testing is needed to evaluate their effectiveness and to more clearly define their limitations. One of the objectives of this study was to use the runoff data obtained to evaluate the applicability of available continuous simulation models for watersheds of the type studied in this project. The drainage area studied is of an intermediate size (7.8 square miles) whereas available models are primarily designed for use on small or large watersheds.

Four models were considered for use in this study. However, one of the models, ARSMOD, which was developed by the Agricultural Research Service of the U.S. Department of Agriculture, is currently undergoing major revisions and as a result was not used in this study. The other three models, Pesticide Transport and Runoff (PTR), Agricultural Runoff Management (ARM) and Nonpoint Source Pollutant Loading (NPS) Models, were developed by Hydrocomp, Inc. under contracts and in cooperation with the U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia (1, 2, 3).

In these models, hydrologic simulation is limited to overland flow. As a result, it is suggested that their use be limited to drainage areas where channel effects are not significant--probably areas up to one to two square miles. The Dee Creek watershed, exceeds this limit. However, in the absence of more

suitable models, these programs were used to evaluate their possible application to larger drainage basins.

Initial calibration efforts were made using the PTR Model. This program provides for simulation of the hydrology, sediment loss and pesticide movement. Hydrologic simulation in this model is similar to the approach used in the Hydrocomp Simulation Program (HSP)(4). One major disadvantage of the PTR Model is its inability to simulate snow melt. Because of this limitation, it was found to be unsatisfactory for use on the Dee Creek watershed.

In February, 1976, information was released on the ARM (Agricultural Runoff Management) Model. This model evolved from the PTR Model and therefore is quite similar except it has provisions for snow melt and nutrient simulation. A simplified flow chart of the ARM Model is shown in Figure 11. As is typical of models of this type, good hydrologic simulation is required before the other components can be calibrated. The general relationship existing between the rate of runoff and the movement of sediment and other components is apparent from Figures 8-10.

Detailed information on the use of the models is provided in the reference manuals. Additional information is also included in two master's theses prepared on this project (5, 6). For information purposes, some of the parameters used in the ARM Model are listed in Table 17.

Input weather data requirements for the ARM Model include precipitation, maximum and minimum daily temperatures and daily values for evaporation, radiation, dewpoint and wind. In this program, soil temperatures are related to air temperatures--which are more readily available. As discussed previously precipitation data were obtained from rain gauges located on the watershed. Other information was obtained from publications of the National Oceanic and Atmospheric Administration for reporting weather stations near the study area. For this study, pan evaporation, wind and air temperature data were obtained from the University of Nebraska

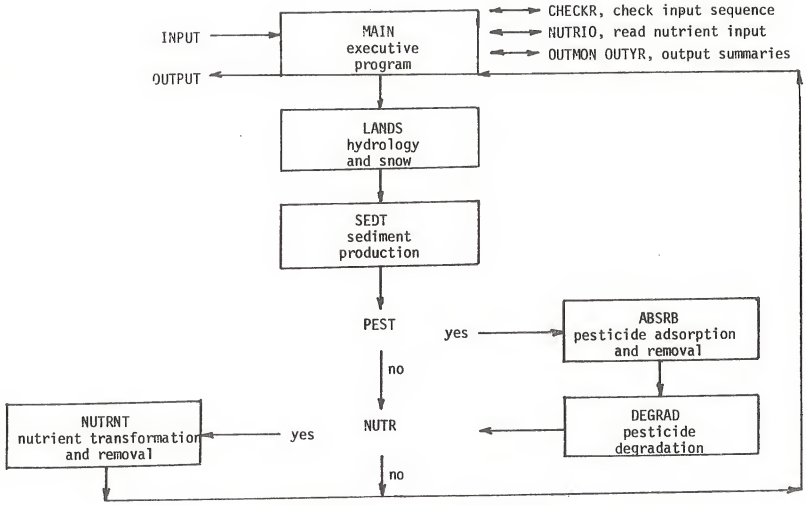


Figure 11: General Structure and Operation of the ARM Model

Table 17

Listing of Hydrology, Snow Melt and Sediment
Parameters Used in the EPA-ARM Model

Hydrology Parameters

A: Fractional area of the watershed which is impervious.

EXPM: An interception storage parameter, related to depression storage prior to occurrence of runoff.

UZSN: Nominal moisture storage in the upper zone, which is the depth of normal tillage or chemical application.

LZSN: Nominal lower zone soil moisture storage. The lower zone is assumed to be approximately six feet deep.

K3: Index to actual evaporation.

K24L, K24EL: Respective parameters controlling the loss of water from near surface to active groundwater storage to deep percolation and transpiration.

INFIL: An index to the mean infiltration rate on the watershed.

INTER: Refers to the interflow component of runoff.

L: Length of overland flow before runoff water reaches a channel.

SS: Average overland flow slope.

NN: Manning's N for overland flow.

IRC, KK24: Interflow and groundwater recession rates.

KV: Parameter for varying groundwater discharge.

Snow Melt Parameters

RADCON, CCFAC: Parameters for adjusting theoretical solar radiation and condensation convection melt equations to field conditions.

SCF: Correction factor for adjusting recorded snow precipitation.

ELDIF: Elevation difference between temperature recording station and the watershed.

IDNS: Density of new snow at 0^{o}F.

F: Fraction of the watershed covered by trees.

DGM: Daily ground melt.

WC: Maximum liquid water content of the snowpack.

MPACK: Estimated water equivalent of the snowpack.

EVAPSN: Adjusts theoretical snow evaporation to field conditions.

MELEV: Mean elevation of each watershed segment.

TSNOW: Temperature below which precipitation is assumed to be snow.

PETMIN, PETMAX: Temperature for adjusting potential evapotranspiration. Below PETMIN evapotranspiration is zero, above PETMAX no adjustment is made.

PETMUL, WMUL, RMUL: Adjustment of input potential evapotranspiration, wind and solar radiation for watershed conditions.

KUGI: Factor for reducing wind in forested areas.

JRER: Exponent in soil splash equation related to rainfall intensity and incident energy.

KRER: Coefficient in the soil splash equation related to the erodibility of the soil.

JSER: Relates overland flow velocity and sediment transport capacity.

KSER: Coefficient in sediment washoff relating slope, overland flow length, sediment particle size and surface roughness.

SRERI, SRERTL: Soil fines initially present on the land surface and (SRERTL) the amount produced by tillage.

COVPMO: Fraction of the soil covered by vegetation on a monthly basis.

Agronomy Laboratory located at Mead, Nebraska. Solar radiation and dewpoint information were obtained from the Omaha, Nebraska National Weather Service Office at Eppley Airfield. A copy of the input data for the Dee Creek watershed is included in the appendix of this report.

Although the NPS Model is similar to the ARM Model, it has the capability of simulating runoff from pervious and impervious areas and therefore can also be used for simulation of runoff from urban areas. While the ARM and NPS Models are similar in their approach to hydrologic and sediment transport simulation, the NPS Model assumes other constituents can be modeled by relating their concentrations in the runoff as a percentage of the quantity of sediment. These relationships are referred to as "potency factors." As discussed later in this report, because of difficulty encountered in calibrating the hydrologic segment of the models, limited progress was made relative to sediment and nutrient modeling. However, potency factors for Dee Creek as determined from the average values for runoff events which occurred during the study period are listed below.

Parameter	Potency Factor
NH_3-N	0.015
NO_3-N	0.11
Sediment N	0.26
Total N	0.38
Inorganic P	0.013
Sediment P	0.023
Total P	0.037
Na	1.1
K	0.43
COD	7.5

Difficulties encountered in calibrating the hydrology of the watershed prevented meaningful evaluation of the sediment transport and nutrient loss segment of the ARM and NPS Models. However, initial calibration runs were made for these components. Parameter values used for the ARM Model are included in the appendix. Assumed values were based on laboratory analyses of runoff samples, information obtained from the Agricultural Research Service and data included in a draft copy of a report on further testing of the ARM Model which was provided by the U. S. Environmental Protection Agency, Environmental Research Laboratory, Athens, Georgia. Fertilizer application data were based on reported usages during the study. It should be emphasized that the parameter values presented are initial estimates and are probably not the values which would be selected based on satisfactory model simulation.

Numerous computer runs were made to calibrate the hydrologic portion of the ARM and NPS Models. Comparisons of monthly simulated and recorded runoff values for some of the runs are presented in Figures 12-15. Simulated versus recorded runoff hydrographs and associated solid concentrations for selected storm events for two computer runs are presented in Figures 16-17. Summaries of simulated monthly runoff values for a run made using the EPA-ARM Model are included in the appendix.

Probably the most difficult period of the year to simulate runoff is during the spring thaw. During this period runoff can occur from the melting process and spring rains. In addition, ground conditions and associated infiltration rates are quite variable. Although the models attempt to simulate snowmelt and ground conditions by using theoretical equations and related input weather data, it is obvious that the results obtained in this study for the month of March were poor. In March 1975 simulated runoff volumes were considerably higher than recorded values, and in March 1976 the reverse was true.

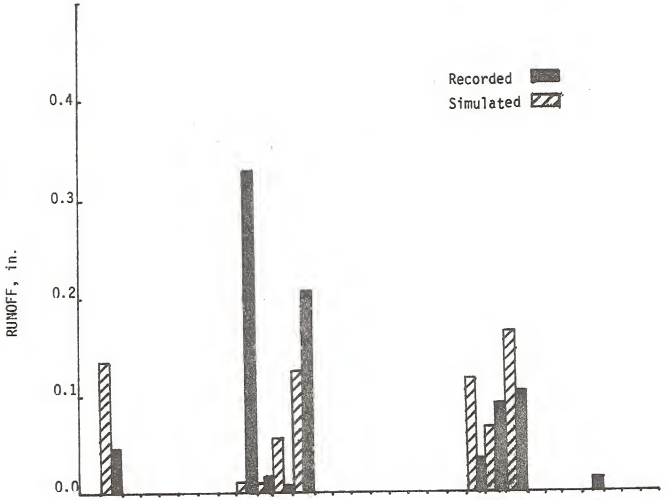


Figure 12: Monthly simulated results for Dee Creek (July, 1974 - December, 1976)

ARM Hydrology Parameter for the Dee Creek Watershed (Figure 12)

UZSN	0.25	A	0.0	IRC	0.10
LZSN	8.0	K3	0.25	K24L	1.00
L	250.0	EPXM	0.06	KK24	0.97
SS	0.043	INFIL	0.07	K24EL	0.01
NN	0.20	INTER	1.00		

Initial Conditions: July 1, 1974

UZS 0.05 LZS 2.50

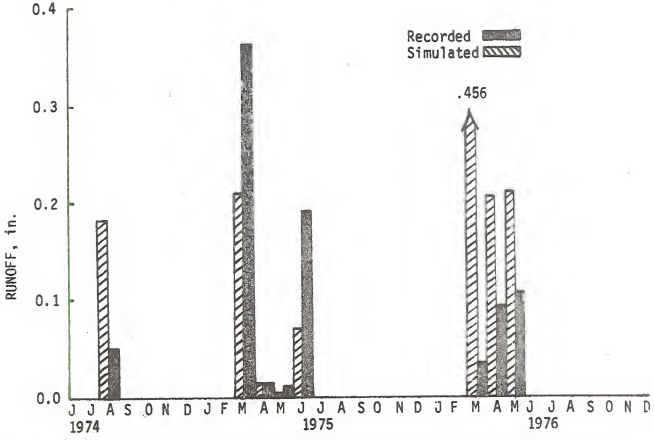


Figure 13: ARM monthly simulation results for Dee Creek (July 1974 - June 1976)

ARM MODEL HYDROLOGY PARAMETERS FOR THE DEE CREEK WATERSHED (Figure 13)

UZSN	0.60	A	0.0	IRC	0.97
LZSN	3.0	K3	0.15	K24L	0.0
L	250.0	EPXM	0.06	KK24	0.10
SS	0.043	INFIL	0.02	K24EL	0.01
NN	0.10	INTER	0.25		

Initial Conditions: July 1, 1974

UZS	0.05	LZS	3.0

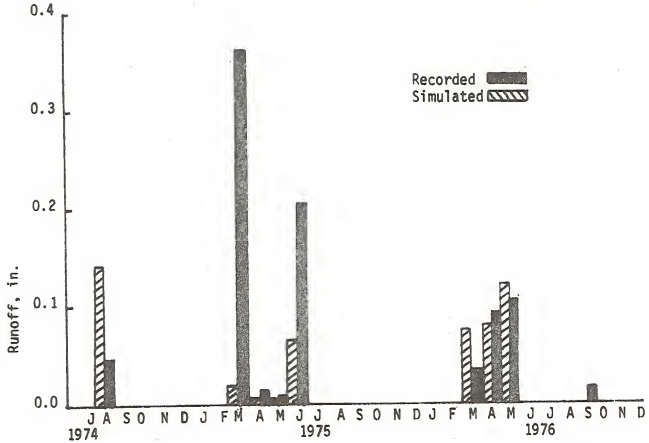


Figure 14: NPS monthly simulation results for Dee Creek (July 1974 - December 1976)

NPS MODEL HYDROLOGY PARAMETERS FOR THE DEE CREEK WATERSHED (Figure 14)

UZSN	0.4	NN	0.2	KI	1.0
LZSN	5.0	L	1000.	PETMUL	1.0
INFIL	0.04	SS	0.035	K3	0.25
INTER	0.7	NNI	0.01	EPXM	0.06
IRC	0.8	LI	0.01	K24L	1.0
AREA	5000.	SSI	0.01	KK24	0.9

Initial Conditions: July 1, 1974

UZS	0.011	LZS	0.724

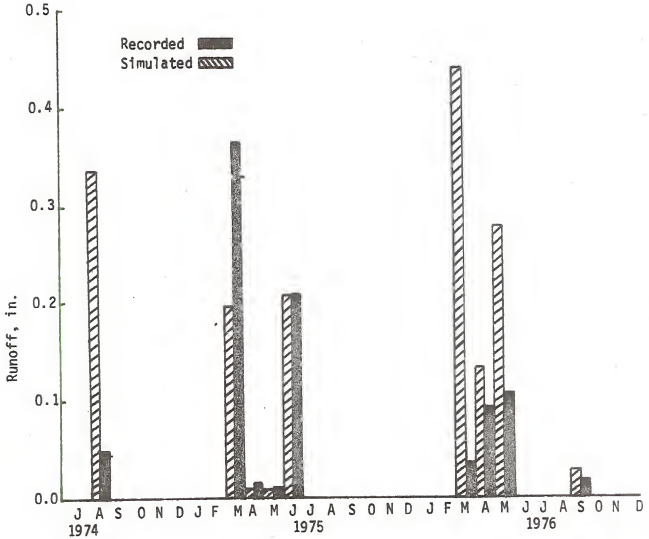


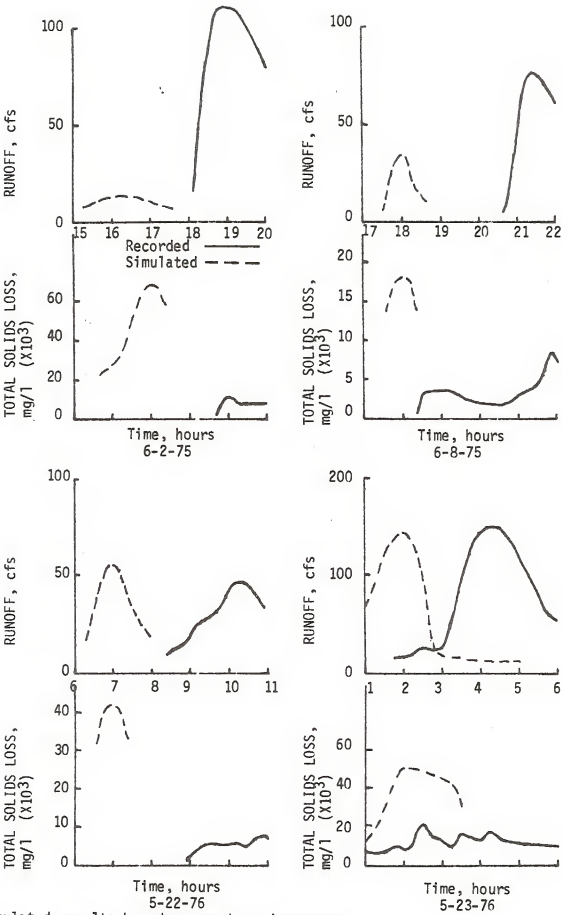
Figure 15: NPS monthly simulation results for Dee Creek (July 1974 - December 1976)

NPS HYDROLOGY PARAMETERS FOR THE DEE CREEK WATERSHED (Figure 15)

UZSN	0.6	NN	0.10	KI	1.0
LZSN	3.0	L	500.	PETMUL	1.0
INFIL	0.02	SS	0.035	K3	0.15
INTER	0.25	NNI	0.01	EPXM	0.06
IRC	0.97	LI	0.01	K24L	0.0
AREA	5075	SSI	0.01	KK24	0.10

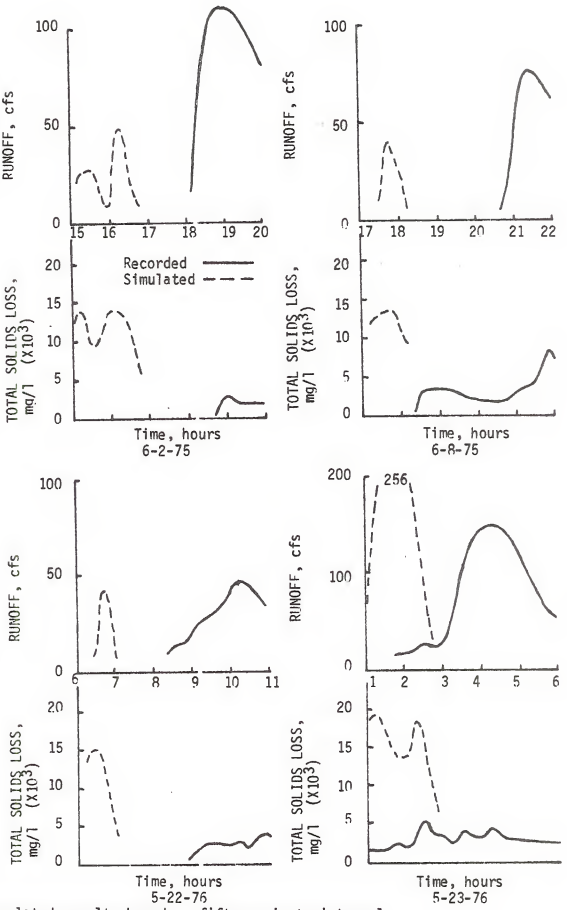
Initial Conditions: July 1, 1974

UZS	0.011	LZS	0.724



Note: Simulated results based on one hour increments

Figure 16: ARM runoff and total solids loss for Dee Creek for selected storm events.



Note: Simulated results based on fifteen minute intervals.

Figure 17: NPS runoff and total solids loss for Dee Creek for selected storm events.

In March 1975, snowmelt occurred over a relatively short period of time as a result of spring rains and warm temperatures. As a result, the ground was frozen and a relatively high percentage of water ran off. On the contrary, during the winter of 1975-76, snowmelt was limited and the runoff event which occurred--March 29--was preceeded by a period of warm temperatures. As a result, limited frost was in the ground, and the infiltration rate was much higher at the time of this major early spring rain. Calibration of this event was also hampered by the fact that only one rain gauging station was operational at the time of this storm. Therefore, the intensity and quantity of rainfall used for this storm may not have adequately represented the average for the watershed.

Except for an infiltration rate adjustment during cold weather--which is included in the models--a constant infiltration rate is used throughout the year. Results of the study indicate a probable change in infiltration rate during the growing season. Reportedly, consideration is being given to modifying the programs to provide varying infiltration rates during the year.

Since some model parameter values provided better simulation in 1974-75 than in 1975-76 and vice versa, the infiltration rate probably also varied on an annual basis. (See Figures 12-15.) This could be attributed to the variance in winter weather conditions, soil moisture conditions at the time of tillage, and noted changes in the crops raised.

One of the major problems encountered in simulating runoff from a drainage area the size of Dee Creek is the variance in the timing, intensity and amount of precipitation over the watershed. In this study, major variations to these factors were noted for some rainfall events. However, input data for the programs represent the average amount of precipitation over the watershed in 15-minute increments. Obviously, this factor becomes much more significant for larger watersheds.

Reportedly, Hydrocomp, Inc. is in the process of developing a stream simulation model for use in conjunction with the NPS Model. By this approach, larger watersheds--such as Dee Creek--could be broken down into desired subbasins and the output from each of these units would serve as input to the stream simulation model. If adequate gauging stations are provided, this approach should minimize difficulties encountered with the handling of precipitation data. Unfortunately, required input data would also be significantly increased.

While drainage channels do not significantly alter the quantity of runoff from a storm event, they do affect the timing and shape of the storm hydrograph. Channel effects in the Dee Creek watershed are apparent from comparisons of simulated and recorded hydrographs. (See Figures 8, 16 and 17.) Generally, simulated hydrographs preceeded recorded values by approximately three hours and were of shorter duration and had higher peak flow rates. These variances were largely attributed to channel effects.

Shape and timing of simulated hydrographs can be changed to some degree by adjusting parameters such as interflow, infiltration rate, soil moisture capabilities, slope and length of overland flow. Suggested methods are available for estimating slope and overland flow values; however, these approaches do not generally account for possible alterations due to conservation practices. Therefore, a range of values was used for all parameters in an attempt to more closely simulate runoff events. Initial values used for average slope and overflow distance were 0.043 foot per foot and 250 feet, respectively.

In summary, results of the study show that the ARM and NPS Models cannot be satisfactorily calibrated for the study watershed. Therefore, parameter values listed for computer runs cited in this report should not be considered

as final calibrated values for the watershed. Since the models were developed for use on smaller watersheds, provisions were not made for variations in precipitation over the drainage area nor stream channel effects. These limitations were major factors in the inability to calibrate the models to the study area. Other factors noted were the inability of the models to adequately simulate field conditions during the period of spring thaw or to adjust infiltration rates during the simulated period. Model calibration was also hampered to some degree by the dry weather conditions prevailing during the study. During the 30-month period, total recorded runoff was equivalent to 0.85 inches, of which approximately half occurred during the spring thaw period. Remaining runoff (0.44 inches) was distributed among 11 events.

Since good calibration was not obtained for the hydrologic portion of these models, limited effort was made to calibrate the sediment and nutrient movement sub-models. As previously mentioned, meaningful calibration of these components is dependent upon good hydrologic modeling.

VI. RESULTS AND CONCLUSIONS

During this study, data were obtained relative to the precipitation, quantity and quality of runoff and farming practices for a 7.8 square mile agriculturally oriented watershed in eastern Nebraska. During the 30-month period, unusually dry weather conditions prevailed and runoff was limited. Therefore, weather conditions must be considered in the use of data included in this report.

Information obtained during this study was used to evaluate the simulation capabilities of two continuous water quality models. Programs studied were the ARM (Agricultural Runoff Management) and NPS (Nonpoint Source Pollutant Loading) Models. It was found that these models could not adequately simulate the hydrology for the watershed. Much of this difficulty was attributed to the fact that these models were developed for use on smaller watersheds--up to one to two square miles. As a result, they do not provide for variations in precipitation over the watershed nor for simulation of stream channel efforts. Data from this study show significant variations in the quantity, intensity and timing of rainfall events over the watershed. Also, there are well defined stream channels in the drainage area. Since these factors affect the quantity and timing of runoff events, use of these models should be limited to small watersheds where the stated simulation concepts more nearly approximate field conditions. One possible approach for using the models is to divide the study watershed into four or five sub-areas with the runoff from each area serving as input to a stream simulation model. It is suggested that this concept be studied when suitable models are available.

Results of calibration runs show that hydrologic calibration was very poor during the normal period of snowmelt. Modifications are needed in the snowmelt and infiltration rate equations in order to more closely simulate field conditions during this period.

Data indicate a change in the infiltration rate in the watershed during the study period. The noted change could be attributed to the formation of major cracks in the soil during the extended dry periods. These cracks provide easy access of rain water to the subsoil thereby bypassing the normal infiltration process until moisture is adequate to swell the soil and seal the openings. Other probable factors influencing the infiltration rate included the noted shift in the type of crop raised in the area, the timing and type of tillage used, and plant growth as related to the resulting root structure. Provision for adjusting infiltration rates within a simulation period, perhaps on a monthly basis, should supply desired flexibility for the models.

Since calibration results on the hydrologic segments of the models were not satisfactory, the sub-models for solids transport and nutrient movement could not be evaluated.

REFERENCES

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3. Donigian, A. S. Jr., and Crawford, N. H., Modeling Nonpoint Pollution from the Land Surface, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. EPA-600/3-76-083, July, 1976.

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5. Stolinski, T. J. Jr., "Computer Modeling for the Prediction of Water Quality from Agricultural Drainage," Unpublished M.S. Thesis, University of Nebraska-Lincoln, 1975.

6. Zuhlke, S. J., "Study of Mathematical Models for Simulating Agricultural Runoff," Unpublished M. S. Thesis, University of Nebraska-Lincoln, 1977.

APPENDIX

NUTRIENT SIMULATION INFORMATION

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**********************************************
*                                            *
*   WARNING: NUTRIENT ALGORITHMS             *
*   HAVE NOT BEEN VERIFIED WITH              *
*   OBSERVED DATA                            *
*                                            *
**********************************************
```

TIME STEP FOR TRANSFORMATIONS = 60 MIN
NUMBER OF NUTRIENT APPLICATIONS = 1
DATE OF PLANT HARVESTING = 253

NITROGEN REACTION RATES	KI	K2	KK2	KD	KPL	KAM	KIM	KKIM	KSA	KAS
SURFACE	2.0000	4.0000	0.0	0.0	0.2500	0.0100	0.0	2.0	4.0000	0.5000
UPPER ZONE	1.0000	4.0000	0.0500	0.0	0.3000	0.0020	0.0	0.0	2.0000	0.3000
LOWER ZONE	0.5000	1.0000	0.0	0.0	0.6000	0.0020	0.0	0.0	1.0000	0.3000
GROUNDWATER	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	0.0
TEMPERATURE COEF.	1.050	1.070	1.070	1.070	1.070	1.070	1.070	1.070	1.070	1.050

PHOSPHORUS REACTION RATES	KM	KIM	KPL	KSA	KAS
SURFACE	0.0200	0.0	0.0100	1.0000	0.0100
UPPER ZONE	0.0020	0.0	2.0000	1.0000	0.0040
LOWER ZONE	0.0020	0.0	1.5000	1.0000	0.0050
GROUNDWATER	0.0	0.0	0.0	0.0	0.0
TEMPERATURE COEF.	1.070	1.070	1.070	1.050	1.050

NUTRIENTS - LB/AC INITIAL STORAGES	ORG-N	NH3-S	NH3-A	NU2	NO3	N2	PLNT-N	ORG-P	PO4-S	PO4-A	PLNT-P	CL
SURFACE LAYER												
AVERAGE	50.	0.0	1.000	0.0	0.500	0.0	5.000	6.	0.0	0.500	1.000	0.0
BLOCK 1	50.	0.0	1.000	0.0	0.500	0.0	5.000	6.	0.0	0.500	1.000	0.0
BLOCK 2	50.	0.0	1.000	0.0	0.500	0.0	5.000	6.	0.0	0.500	1.000	0.0
BLOCK 3	50.	0.0	1.000	0.0	0.500	0.0	5.000	6.	0.0	0.500	1.000	0.0
BLOCK 4	50.	0.0	1.000	0.0	0.500	0.0	5.000	6.	0.0	0.500	1.000	0.0
BLOCK 5	50.	0.0	1.000	0.0	0.500	0.0		6.	0.0			
UPPER ZONE												
AVERAGE	5000.	1.000	9.000	0.0	30.000	0.0	10.000	475.	1.000	30.000	2.000	0.0
BLOCK 1	5000.	1.000	9.000	0.0	30.000	0.0	10.000	475.	1.000	30.000	2.000	0.0
BLOCK 2	5000.	1.000	9.000	0.0	30.000	0.0	10.000	475.	1.000	30.000	2.000	0.0
BLOCK 3	5000.	1.000	9.000	0.0	30.000	0.0	10.000	475.	1.000	30.000	2.000	0.0
BLOCK 4	5000.	1.000	9.000	0.0	30.000	0.0	10.000	475.	1.000	30.000	2.000	0.0
BLOCK 5	5000.	1.000	9.000	0.0	30.000	0.0		475.	1.000	30.000		
LOWER ZONE												
STORAGE	12000.	0.0	20.000	0.0	250.000	0.0	0.0	2000.	0.0	500.000	0.0	0.0

THIS IS A CALIBRATION RUN FOR NUTRIENTS

WATERSHED: DEE CREEK WATERSHED NEAR LINCOLN,NEBRASKA. INPUT SEQUENCE FOR JULY74-JULY75
CHEMICAL:
INPUT UNITS: ENGLISH
OUTPUT UNITS: ENGLISH
PRINT INTERVAL: EACH DAY
SNOWMELT CALCULATIONS PERFORMED

INTRVL= 15	HYMIN= 9.9000	AREA= 5000.0000	
BGNDAY= 1	BGNMON= 7	BGNYR= 1974	
ENDDAY= 1	ENDMON= 7	ENDYR= 1975	

UZSN= 0.2500	UZS= 0.0500	LZSN= 8.0000	LZS= 2.5000			
L= 250.0000	SS= 0.0430	NN= 0.2000	A= 0.0	K3= 0.2500	EPXM= 0.0600	
INFIL= 0.0700	INTER= 1.0000	IRC= 0.1000	K24L= 1.0000	KK24= 0.9700	K24EL= 0.0100	
SGW= 0.0300	GWS= 0.0010	KV= 1.0000	ICS= 0.0900	OFS= 0.0	IFS= 0.0	

RADCON= 1.0000	CCFAC= 1.0000	SCF= 1.0000	ELDIF= 0.0	IONS= 0.1500	F= 0.0100	
DGM= 0.0010	MC= 0.0300	MPACK= 1.0000	EVAPSN= 0.1000	MELEV= 1256.	TSNOW= 33.0000	
PACK= 0.0	DEPTH= 0.0					
PETMIN= 35.0000	PETMAX= 45.0000	PETMUL= 1.0000	WMUL= 1.0000	RMUL= 1.0000	KUGI= 0.0	

COVPHO= 0.20 0.20 0.20 0.20 0.35 0.45 0.65 0.75 0.60 0.45 0.20 0.20
TIMTIL= 213 100 121 151 166 YRTIL= 74 75 75 75 75 SRERTL= 5.000 5.000 8.000 5.000 5.000
SZDPTH= 0.0625 UZOPTH= 0.0000 BULKD= 100.0000
JRER= 2.4000 KRER= 0.3000 JSER= 1.7000 KSER= 2.4000 SRERI= 5.0000

HYCAL=CALB INPUT=ENGL OUTPUT=ENGL PRINT=DAYS SNOW=YES PEST=NO NUTR=YES ICHECK=ON

GROUNDWATER

STORAGE	0.	0.0	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.0

TOTAL NITROGEN IN SYSTEM = 17376.500 LB/AC
TOTAL PHOSPHORUS IN SYSTEM = 3015.000 LB/AC
TOTAL CHLORIDE IN SYSTEM = 0.0 LB/AC

NUTRIENTS - LB/AC	ORG-N	NH3-S	NH3-A	NO2	NO3	N2	PLNT-N	ORG-P	PO4-S	PO4-A	PLNT-P	CL
APPLICATION FOR DAY 110												
SURFACE LAYER												
AVERAGE	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
BLOCK 1	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
BLOCK 2	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
BLOCK 3	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
BLOCK 4	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
BLOCK 5	0.	0.0	5.000	0.0	0.0	0.0	0.0	0.	0.0	0.500	0.0	0.0
UPPER ZONE												
AVERAGE	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0
BLOCK 1	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0
BLOCK 2	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0
BLOCK 3	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0
BLOCK 4	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0
BLOCK 5	0.	0.0	40.000	0.0	0.0	0.0	0.0	0.	0.0	3.600	0.0	0.0

```
THIS IS A CALIBRATION RUN FOR HYDROLOGY AND SEDIMENT ONLY,EPA-ARM MODEL

        WATERSHED:      DEE CREEK WATERSHED NEAR LINCOLN,NEBRASKA. INPUT SEQUENCE FOR JULY75-JUNE76
        CHEMICAL:
        INPUT UNITS:    ENGLISH
        OUTPUT UNITS:   ENGLISH
        PRINT INTERVAL: EACH INTERVAL
        SNOWMELT CALCULATIONS PERFORMED

INTAVL= 15          HYRIN=  9.9000      AREA=  5000.0000
BGNDAY=  1          BGNMON=  7          BGNYR= 1975
ENDDAY=  1          ENDMON=  7          ENDYR= 1976

UZSN=   0.2500      UZS=   0.0140       LZSN=   8.0000      LZS=   3.9660
L= 250.0000         SS=   0.0430        NN=   0.2000        A=   0.0           K3=   0.2500        EPXM=   0.0600
INFIL=   0.0700     INTER=   1.0000     IRC=   0.1030       K24L=   1.0000     KK24=   0.9700     K24EL=   0.0100
SGM=   0.0300       GWS=   0.0010       KV=   1.0000        ICS=   0.0980      OFS=   0.0          IFS=   0.0

RADCON=   1.0030    CCFAC=   1.0000     SCF=   1.0000       ELDIF=   0.0       IONS=   0.1500      F=   0.0100
OGM=   0.0010       VC=   0.0300        MPACK=   1.0000     EVAPSN=   0.1000   MELEV=   1256.     TSNOW=  33.0000
PACK=   0.0         OEPTH=   0.0
PETMIN=  35.0000    PETMAX=  45.0000    PETMUL=   1.0000    WMUL=   1.0000     RMUL=   1.0000      KUSI=   0.0

COVPMO= 0.20  0.20  0.20  0.20  0.35  0.45  0.65  0.75  0.60  0.45  0.20  0.20
TIMTIL= 213  100  121  151  166      YRTIL= 75  76  76  76  76      SRERTL=  5.000   5.000   8.000   5.000   5.000
SZOPTH=   0.0625    UZOPTH=   6.0625     BULKD= 100.0000
JRER=   2.4000      KRER=   0.3000      JSER=   1.7000      KSER=   2.4000      SRERI=   5.0000

HYCAL=CALB  INPUT=ENGL  OUTPUT=ENGL  PRINT=INTR  SNOW=YES  PEST=NO  NUTR=NO  ICHECK=ON
```

SUMMARY FOR MONTH OF JULY 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0		0.0
IMPERVIOUS					0.0	0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.018
						0.018
BASE FLOW						0.001
GROWATER RECHARGE						
PRECIPITATION	0.20	0.20	0.20	0.20	0.20	0.20
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.0
MELT						0.0
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.0
EVAPOTRANSPIRATION						
POTENTIAL	8.83	8.83	8.83	8.83	8.83	8.83
WET	2.28	2.28	2.28	2.28	2.28	2.28
CROP COVER						0.75
STORAGES						
UPPER ZONE	0.0	0.0	0.0	0.0	0.0	0.0
LOWER ZONE	0.557	0.557	0.557	0.557	0.557	0.557
GROUNDWATER	0.011	0.011	0.011	0.011	0.011	0.011
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	5.000	5.000	5.000	5.000	5.000	5.000

SUMMARY FOR MONTH OF AUGUST 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.487	0.044	0.0	0.0	0.0	0.106
INTERFLOW	0.062	0.062	0.001	0.0	0.0	0.025
IMPERVIOUS						0.0
TOTAL	0.549	0.106	0.001	0.0	0.0	0.138
BASE FLOW						0.006
GROWATER RECHARGE						0.061
PRECIPITATION	4.33	4.33	4.33	4.33	4.33	4.33
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.0
MELT						
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						0.0
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.0
EVAPOTRANSPIRATION						
POTENTIAL	5.02	5.02	5.02	5.02	5.02	5.02
NET	2.76	2.76	2.76	2.76	2.76	2.76
CROP COVER						0.60
STORAGES						
UPPER ZONE	0.005	0.003	0.0	0.0	0.0	0.002
LOWER ZONE	1.937	1.937	1.937	1.937	1.937	1.937
GROUNDWATER	0.004	0.004	0.004	0.004	0.004	0.004
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.2						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	1.085	0.040	0.0	0.0	0.0	0.225
FINES DEPOSIT	4.289	5.333	5.373	5.373	5.373	5.148

SUMMARY FOR MONTH OF SEPTEMBER 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.002
						0.002
BASE FLOW						0.004
GROWATER RECHARGE						
PRECIPITATION	0.36	0.36	0.36	0.36	0.36	0.36
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.0
MELT						
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						0.0
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.0
EVAPOTRANSPIRATION						
POTENTIAL	3.63	3.63	3.63	3.63	3.63	3.63
WET	1.35	1.35	1.35	1.35	1.35	1.35
CROP COVER						0.45
STORAGES						
UPPER ZONE	0.0	0.0	0.0	0.0	0.0	0.0
LOWER ZONE	0.941	0.941	0.941	0.941	0.941	0.941
GROUNDWATER	0.002	0.002	0.002	0.002	0.002	0.002
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.290	5.334	5.374	5.374	5.374	5.149

SUMMARY FOR MONTH OF OCTOBER 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.001
BASE FLOW						0.001
GROWATER RECHARGE						0.031
PRECIPITATION	2.38	2.38	2.38	2.38	2.38	2.38
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.0
MELT						0.0
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.0
EVAPOTRANSPIRATION						
POTENTIAL	3.94	3.94	3.94	3.94	3.94	3.94
NET	0.82	0.82	0.82	0.82	0.82	0.82
CROP COVER						0.21
STORAGES						
UPPER ZONE	0.203	0.019	0.0	0.0	0.0	0.044
LOWER ZONE	2.421	2.421	2.421	2.421	2.421	2.421
GROUNDWATER	0.001	0.001	0.001	0.001	0.001	0.001
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.393	5.437	5.477	5.477	5.477	5.252

SUMMARY FOR MONTH OF NOVEMBER 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.000
BASE FLOW						0.000
GROWATER RECHARGE						0.032
PRECIPITATION	0.96	0.96	0.96	0.96	0.96	0.96
SNOW						0.31
RAIN ON SNOW						0.53
MELT & RAIN						0.83
MELT						
RADIATION						-0.12
CONVECTION						0.25
CONDENSATION						0.10
RAIN MELT						0.01
GROUND MELT						0.01
CUM NEG HEAT						0.04
SNOW PACK						0.0
SNOW DENSITY						0.0
& SNOW COVER						0.0
SNOW EVAP						0.00
EVAPOTRANSPIRATION						
POTENTIAL	1.89	1.89	1.89	1.89	1.89	1.89
NET	0.59	0.59	0.59	0.59	0.59	0.59
CROP COVER						0.20
STORAGES						
UPPER ZONE	0.025	0.0	0.0	0.0	0.0	0.005
LOWER ZONE	2.796	2.796	2.796	2.796	2.796	2.796
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.399	5.443	5.483	5.483	5.483	5.258

SUMMARY FOR MONTH OF DECEMBER 1974

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.000
BASE FLOW						0.000
GROWATER RECHARGE						0.006
PRECIPITATION	0.33	0.33	0.33	0.33	0.33	0.33
SNOW						0.17
RAIN ON SNOW						0.07
MELT & RAIN						0.11
MELT						-5.96
RADIATION						0.22
CONVECTION						0.0
CONDENSATION						0.00
RAIN MELT						0.02
GROUND MELT						1.60
CUM NEG HEAT						
SNOW PACK						0.09
SNOW DENSITY						0.93
% SNOW COVER						62.06
SNOW EVAP						0.03
EVAPOTRANSPIRATION						
POTENTIAL	0.81	0.81	0.81	0.81	0.81	0.81
NET	0.09	0.09	0.09	0.09	0.09	0.09
CROP COVER						0.20
STORAGES						
UPPER ZONE	0.021	0.0	0.0	0.0	0.0	0.004
LOWER ZONE	2.897	2.897	2.897	2.897	2.897	2.897
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.007	0.007	0.007	0.007	0.007	0.007
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.399	5.444	5.484	5.484	5.484	5.259

SUMMARY FOR MONTH OF JANUARY 1972

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.000
BASE FLOW						0.000
GROWATER RECHARGE						0.036
PRECIPITATION	1.07	1.07	1.07	1.07	1.07	1.07
SNOW						0.67
RAIN ON SNOW						0.40
MELT & RAIN						0.71
MELT						
RADIATION						-15.77
CONVECTION						0.48
CONDENSATION						0.03
RAIN MELT						0.01
GROUND MELT						0.02
CUM NEG HEAT						3.58
SNOW PACK						0.36
SNOW DENSITY						0.42
% SNOW COVER						69.54
SNOW EVAP						0.08
EVAPOTRANSPIRATION						
POTENTIAL	0.46	0.46	0.46	0.46	0.46	0.46
NET	0.01	0.01	0.01	0.01	0.01	0.01
CROP COVER						0.20
STORAGES						
UPPER ZONE	0.114	0.0	0.0	0.0	0.0	0.023
LOWER ZONE	3.537	3.537	3.537	3.537	3.537	3.537
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.016	0.016	0.016	0.016	0.016	0.016
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.402	5.446	5.486	5.486	5.486	5.261

SUMMARY FOR MONTH OF FEBRUARY 1975

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.000
BASE FLOW						0.000
GRDWATER RECHARGE						0.038
PRECIPITATION	0.61	0.61	0.61	0.61	0.61	0.61
SNOW						0.61
RAIN ON SNOW						0.0
MELT & RAIN						0.57
MELT						
RADIATION						-12.74
CONVECTION						0.22
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.02
CUM NEG HEAT						3.23
SNOW PACK						0.35
SNOW DENSITY						0.92
% SNOW COVER						38.45
SNOW EVAP						0.06
EVAPOTRANSPIRATION						
POTENTIAL	0.84	0.84	0.84	0.84	0.84	0.84
NET	0.03	0.03	0.03	0.03	0.03	0.03
CROP COVER						0.20
STORAGES						
UPPER ZONE	0.277	0.031	0.009	0.0	0.0	0.064
LOWER ZONE	4.010	4.010	4.010	4.010	4.010	4.010
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.008	0.008	0.008	0.008	0.008	0.008
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	4.402	5.446	5.486	5.486	5.486	5.261

SUMMARY FOR MONTH OF MARCH 1975

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.001	0.0	0.0	0.0	0.0	0.000
INTERFLOW	0.040	0.000	0.0	0.0	0.0	0.008
IMPERVIOUS						0.0
TOTAL	0.041	0.000	0.0	0.0	0.0	0.008
BASE FLOW						0.000
GRDWATER RECHARGE						0.212
PRECIPITATION	1.64	1.64	1.64	1.64	1.64	1.64
SNOW						0.28
RAIN ON SNOW						1.36
MELT & RAIN						1.96
MELT						-1.55
RADIATION						0.33
CONVECTION						0.04
CONDENSATION						0.00
RAIN MELT						0.03
GROUND MELT						1.81
CUM NEG HEAT						
SNOW PACK						0.01
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.03
EVAPOTRANSPIRATION						
POTENTIAL	1.52	1.52	1.52	1.52	1.52	1.52
NET	0.35	0.35	0.35	0.35	0.35	0.35
CROP COVER						0.20
STORAGES						
UPPER ZONE	0.268	0.069	0.006	0.0	0.0	0.069
LOWER ZONE	5.395	5.395	5.395	5.395	5.395	5.395
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.000	0.0	0.0	0.0	0.0	0.000
FINES DEPOSIT	4.412	5.456	5.496	5.496	5.496	5.271

SUMMARY FOR MONTH OF APRIL 1975

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.018	0.000	0.0	0.0	0.0	0.004
INTERFLOW	0.013	0.010	0.004	0.001	0.000	0.005
IMPERVIOUS						0.0
TOTAL	0.031	0.010	0.004	0.001	0.000	0.009
BASE FLOW						0.000
GROWATER RECHARGE						0.185
PRECIPITATION	1.88	1.88	1.88	1.88	1.88	1.88
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.00
MELT						
RADIATION						-0.00
CONVECTION						0.00
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.00
CUM NEG HEAT						0.21
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.00
EVAPOTRANSPIRATION						
POTENTIAL	4.08	4.08	4.08	4.08	4.08	4.08
NET	1.98	1.98	1.98	1.98	1.98	1.98
CROP COVER						0.34
STORAGES						
UPPER ZONE	0.075	0.050	0.033	0.026	0.021	0.041
LOWER ZONE	5.186	5.186	5.186	5.186	5.186	5.186
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.009	0.000	0.0	0.0	0.0	0.002
FINES DEPOSIT	5.080	5.089	5.089	5.089	5.089	5.087

SUMMARY FOR MONTH OF MAY 1975

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						0.038
OVERLAND FLOW	0.185	0.004	0.0	0.0	0.0	0.017
INTERFLOW	0.041	0.037	0.004	0.000	0.000	0.0
IMPERVIOUS						0.054
TOTAL	0.226	0.041	0.004	0.000	0.000	
BASE FLOW						0.000
GROWATER RECHARGE						0.152
PRECIPITATION	2.21	2.21	2.21	2.21	2.21	2.21
SNOW						0.0
RAIN ON SNOW						0.0
MELT & RAIN						0.0
MELT						0.0
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						0.0
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.0
EVAPOTRANSPIRATION						4.92
POTENTIAL	4.92	4.92	4.92	4.92	4.92	2.71
NET	2.71	2.71	2.71	2.71	2.71	0.45
CROP COVER						
STORAGES						0.143
UPPER ZONE	0.267	0.211	0.149	0.069	0.016	4.353
LOWER ZONE	4.353	4.353	4.353	4.353	4.353	0.000
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.027
INTERCEPTION	0.027	0.027	0.027	0.027	0.027	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						0.042
ERODED SEDIMENT	0.211	0.001	0.0	0.0	0.0	5.000
FINES DEPOSIT	5.000	5.000	5.000	5.000	5.000	

SUMMARY FOR MONTH OF OCTOBER 1976

	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
WATER, INCHES						
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.000
BASE FLOW						0.000
GROWATER RECHARGE						0.004
PRECIPITATION	0.22	0.22	0.22	0.22	0.22	0.22
SNOW						0.02
RAIN ON SNOW						0.12
MELT & RAIN						0.14
MELT						0.00
RADIATION						0.01
CONVECTION						0.01
CONDENSATION						0.00
RAIN MELT						0.00
GROUND MELT						0.00
CUM NEG HEAT						
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						0.0
SNOW EVAP						0.00
EVAPOTRANSPIRATION						
POTENTIAL	3.59	3.59	3.59	3.59	3.59	3.59
NET	1.05	1.05	1.05	1.05	1.05	1.05
CROP COVER						0.21
STORAGES						
UPPER ZONE	0.0	0.0	0.0	0.0	0.0	0.000
LOWER ZONE	1.857	1.857	1.857	1.857	1.857	1.857
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	5.354	5.354	5.354	5.354	5.354	5.354

SUMMARY FOR MONTH OF NOVEMBER 1976

WATER, INCHES	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4	BLOCK 5	TOTAL
RUNOFF						
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS						0.0
TOTAL	0.0	0.0	0.0	0.0	0.0	0.0
BASE FLOW						C.000
GROWATER RECHARGE						
PRECIPITATION						0.000
SNOW	0.0	0.0	0.0	0.0	0.0	0.0
RAIN ON SNOW						
MELT & RAIN						0.0
MELT						0.0
RADIATION						0.0
CONVECTION						0.0
CONDENSATION						
RAIN MELT						0.0
GROUND MELT						0.0
CUM NEG HEAT						0.0
SNOW PACK						0.0
SNOW DENSITY						0.0
% SNOW COVER						
SNOW EVAP						0.0
						0.0
						0.0
EVAPOTRANSPIRATION						
POTENTIAL						0.0
NET	0.07	0.07	0.07	0.07	0.07	0.07
CROP COVER	0.02	0.02	0.02	0.02	0.02	0.02
						0.20
STORAGES						
UPPER ZONE	0.0	0.0	0.0	0.0	0.0	0.000
LOWER ZONE	1.838	1.838	1.838	1.838	1.838	1.838
GROUNDWATER	0.000	0.000	0.000	0.000	0.000	0.000
INTERCEPTION	0.0	0.0	0.0	0.0	0.0	0.0
OVERLAND FLOW	0.0	0.0	0.0	0.0	0.0	0.0
INTERFLOW	0.0	0.0	0.0	0.0	0.0	0.0
WATER BALANCE= 0.0						
SNOW BALANCE= 0.0						
SEDIMENT, TONS/ACRE						
ERODED SEDIMENT	0.0	0.0	0.0	0.0	0.0	0.0
FINES DEPOSIT	5.354	5.354	5.354	5.354	5.354	5.354